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EDITORIAL

Environmental Science in Developing Countries

This journal has included countless articles devoted to the environmental problems of developing nations. About one-half of all manuscripts submitted to us originate from developing nations and/or deal with environmental issues faced by the less developed countries. The processing of these manuscripts requires attention to particular issues.

A major problem faced by any journal is dealing with the mail. The cost of mailing has increased rapidly during the last decade. Ironically, the increased cost has not increased the speed and reliability of mail but rather decreased them. As expected, the uncertainties in mailing the manuscripts between the editorial office and the authors are somewhat more aggravated in countries with a less established or more limited infrastructure.

The review of manuscripts from many developing nations requires additional steps. Normally, the peer review consists of assurance of scientific quality and contribution to scientific advancement. Occasionally, certain authors appear to be unaware of existing literature and, thus, either duplicate existing information or pay insufficient attention to what is already known. In these cases, the review identifies these shortcomings and establishes the need for a search by the authors. Subsequently, the authors contact library services and obtain the necessary information. In less developed countries, the number of library services is often small and the number of journals available to these services is usually limited. Therefore, the reviewers and the editors must assist the authors in obtaining the necessary information.

Starting with the previous issue of this journal (Volume 15), the cover includes the word "environment" in several languages. It is our desire to demonstrate that environmental protection is an international issue and that our authors and readers originate from many countries. Beginning with Volume 15, the Journal is being produced using a desktop publishing system. The system used by the editorial office is based on a personal computer with the appropriate software and allied equipment.

There are a number of advantages to the desktop publishing system. First, the entire process occurs in the editorial office and, thus, the interaction between the authors on the one side and the editorial staff on the other side requires less time and less mailing. Second, the proofreading by the publisher adds a new quality assurance step, thus reducing the potential for errors. Finally, because the editorial office can make editorial as well as technical judgments, minor corrections can be made, thus avoiding the need for another mailing.

We, like every other scientific journal, must serve our readers. The editors are the advocates for scientific quality, proper organization of the information, usefulness of the information, and ease of understanding of the text. We find ourselves repeatedly emphasizing to our authors the right of our readers to a clear and understandable text. We hope that these new changes are satisfactory to our authors and readers, not only to those in developing nations, but everywhere.

A. Alan Moghissi

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SYMPTOM PATTERNS AS AN EARLY WARNING SIGNAL OF COMMUNITY HEALTH PROBLEMS

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A theoretical argument is presented to justify the use of symptom patterns as early warning indicators of health deterioration in a community. The basic assumption is that people (individuals) and the physical environment (settings) can be treated as probability density functions along a hypothetical health continuum. In practice, the interaction of people and settings results in a bivariate distribution within which a cutoff is placed by decision makers in order to separate the community at large into diagnostic categories of "healthy" and "sick". It is assumed further that changes in the mix of settings and individuals over time can be tracked by health officials as a change in the nature of symptom patterns. Such indicators can give valuable information about the relative health of a community, complementing the conventional use of the incidence rate of specific diseases. Several suggestions are made about how such a theory can be realized through the systematic collection of symptom data that are subsequently treated by multivariate analysis.

INTRODUCTION

For many community health problems the early signs are subjective reports of sensory observations, symptoms, or complaints. However, the "noise" background in such reports is commonly well above the zero level for any community, including the healthy one. Evaluations are based conventionally on measuring the excess incidence and prevalence rates of specific observations, symptoms, complaints, or specific diseases (e.g. eye irritation, chest tightness, odor annoyance, or hospital admissions of asthmatic patients).

The thesis offered here is that changes in the symptom patterns observed in a population over time serve as valuable indicators of impending health problems. In particular, the appearance of new patterns of symptoms may be the first sign of a general deterioration of health, the recognition of which may help the clinician in diagnosing and treating patients and the public health worker in preventing illnesses and treating the environment. When illnesses appear in a community, much time has already been lost for halting further erosion of public health. Furthermore, the criteria for clinically defining disease are so demand-

* To whom all reprint requests should be sent.

ing that much information is lost if only the number of diseased patients is used for evaluating community health. In an early warning system, it is important to notice changes in population symptom patterns which may be acted upon faster and, thereby, considerably increase the data base for decisions.

According to Pennebaker (1982) symptoms are subjective in nature. Subjective symptoms should be distinguished from physical signs of ill health, such as fever or cardiac arythmia. Our theoretical analysis is couched in terms of symptoms and the patterns (constellations) they form when observed together in the same individual or in a group of individuals. Exactly the same analysis would hold if physical signs were used as indicators of health instead of symptoms (see also Berglund and Lindvall 1986).

The role of symptom patterns can be seen more clearly within the broader context of public health decision making. A working model of such a process is diagrammed in Fig. 1. The major components of this process are the target population (I = individuals), the specific environment occupied by the population (S = settings), and the public health evaluation bodies and their decision-making rules (f(I), f(S)). At any point in time we assume both the population and the environment can be hypothetically characterized by their various states of health along some dimension of epidemiological interest (physical, psychological, or social well being; e.g. see Lilienfeld and Lilienfeld 1980). The target population is represented as a distribution of individuals (I) over a hypothetical health dimension, and the environment is similarly represented as a distribution of settings (S) over this same dimension. In effect, we are assuming that individuals vary in their predispositions for illness (host sensitivity), the basis for which is not relevant to the present model. As an abstraction, the health dimension, which depends on both the host and the environmental factors, need not be subject to direct measurement, but points along it can be evaluated indirectly by using this model. A poorly ventilated office building standing on the former site of a chemical dump can be considered an unhealthy setting; a person afflicted with atopic allergy may be said to possess a sensitive constitution. No attempt is made here to define or equate states of health for settings and individuals, beyond assuming that they are situated along the same health dimension. In addition, exactly how an environment or an individual arrived at their present states of health is outside the domain of the model. Only present states of the individual as well as the environment are relevant and measurable.

The observed health of a population depends on both the state of the people and of the environmental settings in which they live and work. It is the interaction between people and settings that determines the wellness of the population as a whole. The particular interaction depends on complex factors in the human body and in the physical and societal environment. As schematically shown in Fig. 1, the end result, however, is a combination rule operating to form the joint distribution of individuals (I) and settings (S) based on all the values of the two separate distributions ($i_1, i_2 \ldots i_n ; s_1, s_2 \ldots s_n$). In the special case where these two distributions are statistically independent, there exists a complete mix of types of individuals and types of settings that vary jointly in their state of health. For example, there will be a small number of individuals who are exceptionally healthy and unlikely to become ill no matter how dismal their environments are. At the opposite end of the continuum, there is a corresponding small group

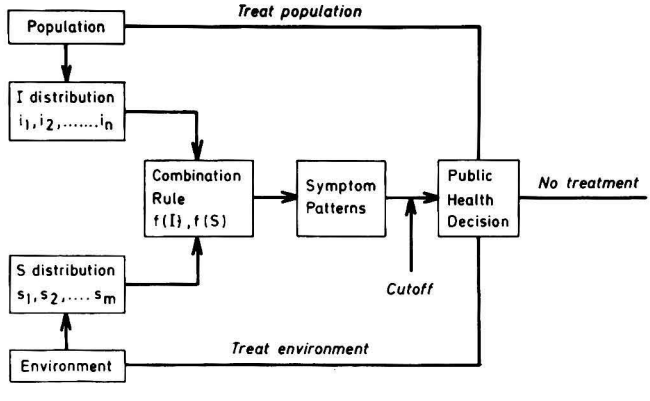

Fig. 1. Schematic model of a community health system.

of individuals who display disease in most physical settings. In the case where the health inclination of individuals and the environments are not statistically independent, selection mechanisms in a population may result in a situation where healthy individuals are found in unhealthy environments more frequently than are unhealthy individuals (e.g. healthy worker effect). The absolute wellness of a population or an environment, therefore, cannot be decided categorically but, rather, sickness and health are graded states that vary throughout the society.

By noting the form and course of changes in an established pool of symptom patterns, one may be able to anticipate a deterioration of health. New symptom patterns are likely to signal a major, qualitative shift in the interaction between individuals and settings. For example, the introduction of new building materials, emitting new combinations of chemicals, may be followed by the appearance of a new array of medical symptoms. In an occupational setting, a major turnover of personnel in a particular line of work could be accompanied by a new mix of host sensitivities and impact risks of environmental hazards.

The scientific rationale for focusing on the recognition of symptom patterns is further elaborated by a quantitative example of the process diagrammed in Fig. 1. We offer preliminary suggestions about how one might proceed to initiate an early warning system based on these theoretical ideas.

A QUANTITATIVE MODEL OF COMMUNITY HEALTH

We first assume there is a hypothetical health dimension which stretches from sickness at one end to wellness at the other. Values along this dimension indicate varying states of health existing at a single moment in time. As presently envisioned, the model is static. These health states can also be treated as predispositions toward health or illness in the future, but this is not a crucial part of the present model.

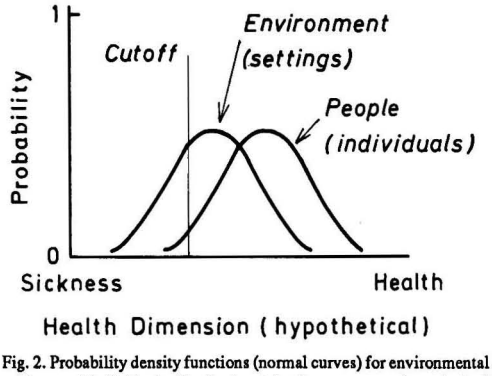

Fig. 2. Probability density functions (normal curves) for environmental settings and individuals. The horizontal axis represents a hypothetical health dimension. The cutoff (C) separates sick and healthy states defined by the areas under each curve to the left of the cutoff value.

Our second assumption is that both individuals and environmental settings can be represented as probability density functions over the health dimension. Examples of two possible functions are illustrated in Fig. 2. By this assumption we imply that, in principle, the health of the population can be assessed for every individual or for some target group of individuals, and that, in principle, the health of different environmental settings can also be determined. The height of the curve at each point along the health dimension indicates the probability of finding either an individual or a setting with that particular degree of health. The methods for determining the probabilities for different health states are not discussed here since they ar not important for the theoretical idea.

Thirdly, we postulate a cutoff along the health dimension, set by the decision maker (physician, risk manager, etc.). The cutoff serves as a boundary between health and sickness. The areas under each curve to the left of the cutoff in Fig. 2 represent the percentages of the total number of individuals and settings considered "sick". The presence of this cutoff does not mean that states of health and sickness are in some sense absolute. The cutoff exists only as a convenient way to decide whether the level of illness requires action on the part of the decision maker. Different decision makers may differentially weigh the relevance of the medical symptoms observed in the population as well as the environmental characteristics and, hence, locate the cutoff at different places along the health dimension. Minor modification of the model would allow separate cutoffs for individuals and settings. This possibility is not pursued here.

The fourth major assumption is that a correlation ($r = -1$ to $+1$) exists between the health of individuals and the health of environmental settings to which such individuals are exposed. This corresponds to the combination rule in Fig. 1. For the purpose of this analysis, the most dominant environmental setting (in terms of health implications) for an individual is considered to stand for all those to which the individual is exposed. Depending on the particular population-environment constellation under discussion, this correlation could be 0 (no relationship between the health of people and settings), positive (sick people in sick settings, well people in well settings), or negative (sick people in healthy settings, healthy people in sick settings).

In order to illustrate these ideas with an example, we further restrict the general model as follows. First, we assume that each of the two probability density functions (Fig. 2; symbolized with x and y) is a normal Gaussian with mean (μ_x) and standard deviation (σ_x) for individuals, and with mean (μ_y) and standard deviation (σ_y) for settings. In addition, the two density functions are taken to be independent ($r = 0$). The distributions can then be described by Eqs. 1 and 2.

$$f(x) = \frac{1}{\sigma_x\sqrt{2\pi}}\, e^{-(1/2)\left[(x-\mu_x)/\sigma_x\right]^2} \tag{1}$$

$$f(y) = \frac{1}{\sigma_y\sqrt{2\pi}}\, e^{-(1/2)\left[(y-\mu_y)/\sigma_y\right]^2} \tag{2}$$

Since the two density distributions are independent, we multiply their respective probabilities in order to find the joint probability of people and settings for various levels of health. We are interested in the health of the entire population in all possible settings, so the entire distributions (Eqs. 1 and 2) are multiplied, yielding the bivariate normal

$$f(x,y) = f(x)\,f(y)$$

which by substitution is

$$f(x,y) = \frac{1}{2\sigma_x\sigma_y\pi}\, e^{\left\{-(1/2)\left[(x-\mu_x)/\sigma_x\right]^2 - (1/2)\left[(y-\mu_y)/\sigma_y\right]^2\right\}} \tag{3}$$

This can be written more succinctly by noting that the exponent contains two standardized scores. Let

$$z_x = \frac{x-\mu_x}{\sigma_x} \quad \text{and} \quad z_y = \frac{y-\mu_y}{\sigma_y}$$

Substituting in Eq. 3:

$$f(x,y) = \frac{1}{2\sigma_x\sigma_y\pi}\, e^{-(1/2)\left[z_x^2 + z_y^2\right]} \tag{4}$$

An example of this joint density function is illustrated in Fig. 3 for the case where the distribution means both are 0, and the standard deviations both are 1.

$$\mu_x = \mu_y = 0 \quad \text{and} \quad \sigma_x = \sigma_y = 1$$

In the figure, the X and Y axes each represent values along the same underlying health dimension depicted in Fig. 2, but the single dimension is evaluated jointly for individuals (X) and settings (Y). That is, the height of the function above any point represents the probability of finding an individual of a certain health status at a setting of a certain health status, where both values can range from sickness to health. Since the resulting bivariate distribution is meant to define a probability space, its cumulative probability is 1.

$$\iint f(x,y)\,dx\,dy = 1$$

To find the cumulative percentage of individuals-settings falling below a criterion for the value judgment "sick" (cutoff = C; to simplify here the same cutoff is being applied for both X and Y), we integrate Eq. 4 over the region of a space bounded by the area $C \times C = R$. That is, the probability that x,y is in region R is defined as:

$$P\left[(x,y)\,\text{in}\,R\right] = \frac{1}{2\sigma_x\sigma_y\pi} \iint_R dx\,dy\, e^{-(1/2)\left[z_x^2 + z_y^2\right]} \tag{5}$$

The location of region R in respect to the bivariate normal can be appreciated better from a station point above the distribution. Such a top view is schematized in Fig. 4, which shows several circular contour lines of equal probability as well as the region ($C \times C = R$) enclosing all the combinations of individuals and settings that show illness. The approximate percentage of people in this region would show up for the decision maker in the total number of reported medical symptoms.

It is not our goal to suggest which institution, government office, or individual should decide upon acceptable levels of sickness in a population. Once a cutoff (C) is chosen along either the dimension for individuals and/or the dimension for settings, it is possible to use the present theoretical model to explore the potential impact of various actions to improve the health of a population and/or its environmental settings. The general model (Eq. 5) will still hold for alternative probability density functions. Within the context of our view (Fig. 1) improvement treatments are seen as parts of feedback loops that

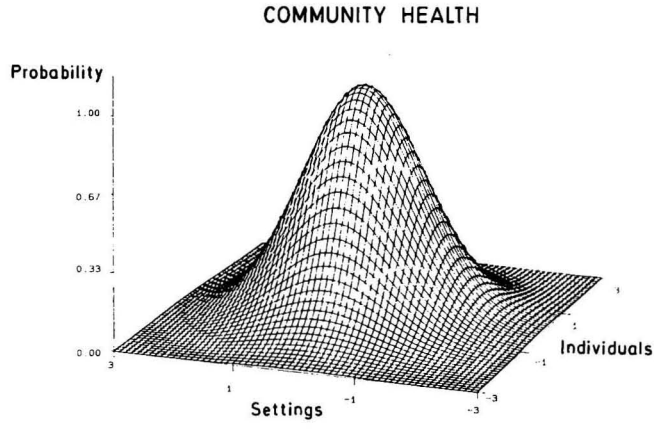

Fig. 3. Bivariate normal distribution representing the health of individuals and settings ($\mu_x = \mu_y = 0$ and $\sigma_x = \sigma_y = 1$).

continually modify the type and frequency of symptom patterns. The theoretical impact of these treatments can be simulated by varying the means, standard deviations, and correlation between the two univariate distributions (X and Y), and then noting the corresponding changes in the integral (Eq.5). Such an exercise is definitely related to the question of "disease frequency". Furthermore, it is an argument for the use of symptom patterns as early warnings for environmentally related health disorders which also takes into account qualitative pattern changes. Thus, the subtle benefit of the model is its emphasis on the joint consideration of people and settings as a precursor of community illness.

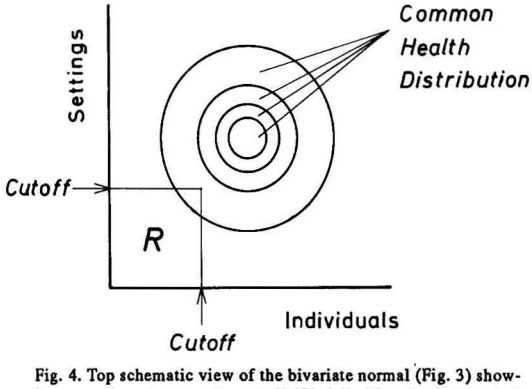

Fig. 4. Top schematic view of the bivariate normal (Fig. 3) showing several contours and a cutoff (C) delimiting the bottom left area (R) of "sickness". The X and Y axes represent individuals and settings, respectively.

SYMPTOM PATTERNS AS WARNING SIGNALS

A change in the nature of symptom patterns can indicate either an improvement or a degradation in health. A deterioration of health could occur either by changing the health of individuals or settings. If the cutoff (C) remains fixed, then shifting the mean of the distribution in the direction of the "sick" end of the dimension or increasing the variance of either univariate distribution will produce a greater volume of sickness. That is, the target region (R) will be responsible for a greater fraction of the volume under the bivariate distribution. Such changes have implications for symptom patterns as well. As more and more of the bivariate distribution crosses over to the "sick" side of the cutoff, the variety of symptom patterns can be expected to increase. That is, since new combinations and types of individuals and settings (formerly considered well) are now included in the region of illness, we can expect to see a more varied set of medical symptoms. The characteristics of the newly-included settings and people are by definition different from those types which formerly were considered sick, and hence, we should observe an expansion of symptoms not only with regard to frequency but more importantly to the patterns of symptoms. Note also that this would be true even in the case where only one of the univariate distributions shifted to the sick side or became more variable. For example, the introduction of unhealthy building materials could diminish the environmental quality while the health of the exposed population is constant. The new mix between sick settings and people would result in

the appearance of new symptoms or novel groupings of old symptoms.

Another possibility is that the health of the environment (or individuals) deteriorates while at the same time the health of the population (or environment) improves. Losses in one aspect of public health may be totally offset by gains in another. The frequency of illness in this event would remain the same, and therefore, would not be a valid indicator of what is actually a potentially dangerous situation. On the other hand, a change in symptom patterns might be noticed. Early detection of new patterns could signal the need for corrective action.

One final example will be given. Different sociological structures allow for different degrees of mobility among their citizens. This could have very marked consequences for the entire health perspective. Consider the following hypothetical situation. A new paint product becomes available and quickly seizes a substantial fraction of the market. In particular, thousands of square meters of inside walls are covered with this product. Unfortunately, the paint contains a solvent that creates a variety of unique sensory symptoms (e.g. eye irritation, hoarseness in the throat). Because of differences in their predispositions, some people exposed to the new paint exhibit these symptoms while others do not. Now imagine two stereotypical forms of society, one that is occupationally highly mobile and another which is extremely low in mobility. In the society with low mobility, it is soon obvious that something is wrong, based on both a change in symptom patterns and on the increase in clinical cases. On the other hand, in the mobile society, those individuals who are adversely affected by the new solvent will leave their jobs and find new employment elsewhere. This is a well known phenomenon called the healthy worker effect. If this happens, there will not be an increase in the total number of reported illnesses, even though there are definite new health hazards.

The impact of the healthy worker or citizen effect on the symptom patterns as a whole in the exposed population is hard to predict. We might expect an overall change in symptom frequency or types because there is a new mix of people and settings. The overt response to the paint might gradually disappear in the population as a whole, despite the fact that nothing whatsoever was done to improve the state of the environment. Taken to its limit, a mobile society could end up with all its healthy citizens occupying unhealthy settings, and all its unhealthy citizens occupying healthy settings (negative correlation between the health of people and settings). Under such circumstances, minor changes in the health status of the environment or the population could have dramatic consequences. That is, there must be a limit in any society on the degree to which mobility (healthy citizen effect) can be utilized for problem solving in the domain of public health. When pushed even slightly beyond this limit, a population may show adverse health effects of unforeseen proportions.

IDENTIFICATION OF SYMPTOM PATTERNS

The first requirement for using symptom patterns for early warnings is access to current data bases on relevant medical symptoms. Such data bases could include results from survey questionnaires (e.g. Pennebaker 1982). However, the subjective symptoms asked for in the questionnaire have to be of a more refined and elaborate type than has been true so far in assessing symptoms. In addition, the questionnaire must be constructed according to sound principles commonly employed for other psychometric tests (e.g. Lord and Novick 1968). Statistical techniques would have to be applied that categorically distinguish among symptom patterns and sharply delineate the relationships among patterns in terms of similarity, severity, etc. This can be accomplished by conventional multivariate techniques which have already proven successful in studies of air pollution (Baird et al. 1984; Baird et al. 1987; Noma et al. 1987; Berglund et al. 1982). Finally, pattern recognition analyses (see e.g. Andrews 1972; Baird and Noma 1978; Coxon 1981; Varmuza 1980) could be used to describe whether significant changes have occurred over time. In epidemiological studies, the nature and time course of symptom patterns may constitute a sensitive indicator of community health.

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RESERVOIRS AND VEHICLES OF SALMONELLA INFECTION ON GUAM

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A review of laboratory records covering a 17-year period suggested that stray dogs and wild lizards are the animals most likely to be responsible for the high prevalence of *Salmonella* contamination of soil previously reported on Guam. The observation that home vacuum cleaners also frequently contain *Salmonella* bacteria has led to development of the hypothesis that the high incidence of infant salmonellosis on Guam may be the result of this contaminated soil being tracked into homes on footwear.

INTRODUCTION

Guam is a self-governing island territory of the United States of America located in the western Pacific Ocean. Approximately 2400 km due east of Manila in the Philippines and 2400 km south of Tokyo, Japan, Guam enjoys a year-round tropical climate with daily temperature extremes ranging from an average low of 76°F (24°C) to an average high of 86°F (30°C). The recorded low and high temperature are 65°F (18°C) and 96°F (35°C), respectively; the mean annual rainfall is 216 cm (Mundy 1983).

The incidence of laboratory-confirmed human salmonellosis on Guam rose from 11 cases per 100 000 population in 1973 to 218 cases per 100 000 population in 1984. By 1987 it had declined to 111 per 100 000. About 50% of all human cases were less than one year of age (age-specific incidence of 3975 per 100 000 for infants in 1984) and about 40% of the human isolates were *S.waycross*, a serotype that is rare in other countries. Other aspects of salmonellosis on Guam have been described (Haddock and Delon 1980; WHO 1983).

Efforts to incriminate animal-origin foods as a source of the hyperendemic incidence of salmonellosis on Guam have been unsuccessful (Haddock and Malilay 1986). Unusually high levels of *Salmonella* in soil (Haddock and Nocon 1986) and vacuum cleaners (Haddock 1986), however, have led to the development of a hypothesis that *Salmonella* infections, particularly those in infants, may arise from contamination carried into homes on footwear. A review of salmonellosis surveillance activities was conducted to evaluate the possible role that various reservoirs and vehicles of *Salmonella* might play in the contamination of Guam's environment and the spread of salmonellosis on the island.

MATERIALS AND METHODS

Records of all nonhuman specimens submitted to the Guam Public Health Laboratory for bacteriologic analysis from 1971 through 1987 were reviewed. The type of specimen and the *Salmonella* serotypes isolated, if any, were recorded. Specimens which were subjected only to quantitative analysis (such as coliform plate counts) were not included in the study. While specimens included those collected during the investigation of salmonellosis cases, the majority were the result of special surveillance activities.

Food and water specimens were collected in sterile plastic containers, animal stool and moist environment samples were collected using sterile cotton-tipped swabs, and dry environmental surfaces were sampled using "elephant" swabs (2" x 2" gauze surgical sponges wrapped around wooden tongue depressor blades and autoclaved). Soil and vacuum contents samples were collected in sterile plastic containers using sterile wooden tongue depressor blades. Intestinal contents of lizards were collected by aspetic dissection, turtles were tested by collecting a sample of water from their cage. Samples were placed in Selenite-F enrichment broth (cotton tipped swabs and lizard intestine contents in 25 mL, other samples in 250 mL) and incubated for 24 hours at 37°C. The specimens were then plated on *Salmonella-Shigella* and Brilliant Green (Difco) agar plates. Following incubation for another 24 hours at 37°C, suspect colonies from the plates were stabbed and streaked into triple sugar iron agar (TSIA) and lysine iron agar (LIA) slants. Biochemical tests to determine the presence of *Salmonella* were performed on suspect isolates following an additional 24-hour incubation period at 37°C. An agglutination reaction performed on the culture from the TSIA slant using *Salmonella* O Antiserum Poly A-1 confirmed identification of the bacteria, and positive specimens were then serotyped.

RESULTS

A total of 2405 specimens of environmental, food, and animal origin were examined for the presence of *Salmonella* during the period from 1971 to 1987 (Table 1). *Salmonella* isolation rates varied but were much higher among samples from animals (18.7%) and the environment (17.2%) than among food and animal feed samples (1.4%).

Among animals tested, poikilothermic species (lizards, turtles and toads) were the most frequently positive for *Salmonella*. Skink lizards were the most common animal source of *S.waycross*. Cats (28.6%) were more frequently positive for salmonellosis than dogs (15.0%), but *S.waycross* was recovered only from dogs (6.0%).

Salmonella bacteria were recovered from 7 of 65 (10.8%) of confined dogs tested and from 8 of 35 (22.9%) of strays tested. *S.waycross* was isolated from 2 confined dogs (3.1%) and 4 (11.4%) strays. Six of 27 (22.2%) dogs associated with a human case of salmonellosis were positive for *Salmonella* and in 3 separate instances (1 stray dog shedding *S.javiana*, 1 stray and 1 confined dog each shedding *S.waycross*) the same serotypes were isolated from both human patients and the dogs with which they had direct or indirect contact. A skink lizard was the only other animal shedding *Salmonellae* of the same serotype as a human case associated with it.

Among food items, *Salmonellae* were detected only in animal feed ingredients (meat, bone, or fish meal, 34.6%), cooked chicken (6.7%), cooked rice (1.0% for "other cooked foods"), and uncooked seafood items (2.3%). *S.waycross* was encountered only once in food samples (cooked chicken).

Among environmental samples, vacuum cleaner contents (34.6%), ocean waters (32.8%), soil (21.2%), animal feed plant environment (18.2%), freshwater streams (17.3%), and digested sewage sludge samples (16.7%) were most frequently positive for *Salmonella*. Esturine ocean waters and vacuum cleaner contents were the most frequent sources of *S.waycross* isolates (12.5% and 4.7% of sampled positive, respectively).

DISCUSSION

Despite the high incidence of salmonellosis on Guam, food poisoning outbreaks in which *Salmonella* is incriminated as the agent are rare events on the island (Haddock and Kampelmacher 1986). This fact, in addition to the observation that most food stuffs consumed on Guam are imported from the United States where *S.waycross* is extremely rare (only 3 of 35 862 *Salmonella* isolates reported to the National Centers for Disease Control in 1984 were *S.waycross* [CDC 1984], all three were from Guam residents treated for illness in Hawai), has led us to believe that this problem is not primarily a food-related one. The high *Salmonella* contamination rates of soil and vacuum cleaners on Guam suggests that these bacteria may be tracked into homes on footwear to infect the inhabitants via routes other than ingestion of contaminated food. Even though the numbers of bacteria involved in such a process might be quite small, infants, by virtue of their greater susceptibility, might develop symptomatic infections while other more resistant family members do not (Blaser and Newman 1982). Under these conditions, the respiratory route of infection could be important (Bate and James 1958).

A comparison of the frequency with which different *Salmonella* serotypes were isolated from humans, animals, and the environment on Guam reveals a number of interesting observations (Table 2). While products such as meat, fish, and bone meal used in the manufacture of animal feeds were a fruitful source of exotic *Salmonella* serotypes, they did not appear to be significantly involved in local transmission cycles.

Their potential for introducing new serotypes into the local ecosystem cannot be dismissed, however.

Although none of the 35 countries cooperating in the WHO *Salmonella* Surveillance Program for 1986 reported *S.waycross* among the 15 most commonly isolated serotypes in their country (WHO 1986), on Guam *S.waycross* has been the serotype most commonly isolated from humans as well as animals and

Table 1. Nonhuman sources of *Salmonella* isolations on Guam, 1971-1987.

SPECIMEN	Total Tested	Number (%) Positive for *Salmonella*	Number (%) Positive for *S.waycross*
Ocean waters	64	21 (32.8)	8 (12.5)
Streams	191	33 (17.3)	3 (1.6)
Sewage	46	4 (8.7)	1 (2.2)
Sewage sludge	6	0	0
Swimming pools	9	0	0
Kitchen environment	87	0	0
Home environment	48	0	0
Vacuum cleaner contents	107	37 (34.6)	5 (4.7)
Animal food plant	22	4 (18.2)	0
Soil	212	45 (21.2)	6 (3.3)
Hospital environment	49	0	0
Total environment samples	**841**	**145 (17.3)**	**23 (2.7)**
Tap water	418	0	0
Packaged dry food	115	0	0
Raw milk	18	0	0
Processed milk	20	0	0
Baby formula	6	0	0
Breast milk	1	0	0
Chicken, uncooked	11	0	0
Seafood, uncooked	129	3 (2.3)	0
Red meat, uncooked	29	0	0
Other uncooked foods	91	0	0
Chicken, cooked	15	1 (6.7)	1 (6.7)
Seafood, cooked	7	0	0
Other cooked foods	97	1 (1.0)	0
Animal feed ingredients	26	9 (34.6)	0
Finished animal feeds	20	0	0
Total food samples	**1 003**	**14 (1.4)**	**1 (0.1)**

Table 1 continued.

Dog	100	15 (15.0)	6 (6.0)
Cat	7	2 (28.6)	0
Chicken	42	6 (14.3)	0
Rodent	14	2 (14.3)	0
Cattle	27	2 (7.4)	0
Horse	1	0	0
Duck	3	0	0
Pet birds	3	0	0
Pigs	31	9 (29.0)	1 (3.2)
Other pet animals	5	0	0
Toad (*Bufo marinus*)	14	9 (64.3)	0
Snake (*Boiga irregularis*)	15	2 (13.3)	0
Gecko (*Hemidactylus sp.*)	216	13 (6.0)	3 (1.4)
Anole (*Anolis carolinienesis*)	21	16 (76.2)	1 (4.8)
Skink (*Carlia sp.*)	21	11 (52.4)	2 (9.5)
Turtle (*Pseudemys sp.*)	28	18 (64.3)	0
Insects	13	0	0
Total animal samples	**561**	**105 (18.7)**	**13 (2.3)**

the environment during the period covered by this study (Table 2). This strongly suggests an important relationship between humans, animals, and their shared environment in the epidemiology of this disease. In fact, five other *Salmonella* serotypes also appear among the serotypes most commonly isolated from humans, animals, and the environment on Guam; thus this phenomenon is by no means limited to the *S.waycross* serotype.

Salmonella waycross was isolated once from a food item (an ethnic dish of diced, cooked chicken mixed with shredded coconut, lemon juice, onions, and peppers). Negative follow-up studies of chicken from the same source (frozen U.S. origin) suggested that it had been contaminated during preparation although the suspect food handler quit her job and could not be located for examination.

Ocean waters examined were generally from estuarine areas known to be receiving pollution from fresh water streams (probably contaminated by septic tank leaching fields as well as animal waste) and surface rain water run-offs (probably contaminated mainly by animal waste). Neither direct or indirect contact with such waters is likely to account for many cases of infant salmonellosis but, as in the case of sewage sampling, their testing may be a useful tool for surveillance of *Salmonella* in the community.

Although pet baby turtles have been considered an important cause of salmonellosis in other areas (Lamm et al. 1972), no cases of salmonellosis on Guam were associated with turtle ownership during the study period and *S.waycross* was never isolated from turtles on Guam. It is concluded that turtles have not been an important cause of salmonellosis on Guam.

Various lizards show a relatively high *Salmonella* infection rate compared to other animals but infants would not generally be exposed directly to them. It would also seem that their relatively small body mass, as well as limited range, make them an unlikely major source of the observed contamination of soil in Guam. On the other hand, stray dogs, a serious public nuisance problem on Guam, are far ranging, indiscriminately depositing substantial quantities of feces wherever they travel, and could be an important vector. Flies, attracted to and breeding in dog feces, could also contribute to the *Salmonella* infection rate observed in lizards.

Table 2. The ten *Salmonella* serotypes most commonly isolated from humans, animals, and the environment, Guam 1971 to 1987.

HUMANS	ANIMALS	ENVIRONMENT
1. *S. waycross*	1. *S. waycross*	1. *S. waycross*
2. *S. oranienburg*	2. *S. amager*	2. *S. amager*
3. *S. amager*	3. *S. oranienburg*	3. *S. houten*
4. *S. newport*	4. *S. newport*	4. *S. oranienburg*
5. *S. java*	5. *S. braenderup*	5. *S. aberdeen*
6. *S. weltevreden*	6. *S. tennessee*	6. *S. java*
7. *S. aberdeen*	7. *S. urbana*	7. *S. brazil*
8. *S. typhimurium*	8. *S. javiana*	8. *S. give*
9. *S. virchow*	9. *S. Virchow*	9. *S. virchow*
10. *S. give*	10. *S. aberdeen*	10. *S. newport*

[1]Isolations from samples of human food and drink (957 tested), finished animal feeds (20 tested), and animal feed ingredients (26 tested), while too few to draw significant comparisons, included 1 *S.waycross* (cooked chicken), 1 *S.anatum* (cooked rice), 2 *S.infantis* and 2 *S.tennessee* (animal feed ingredients) and 1 each *S.agona, S.manila, S.mbandaka, S.meleagridis, S.montevideo, S.newington, S.schwarzengrund, S.senftenburg, S.simsbury,* and *S.thomasville* (animal feed ingredients).

Gecko lizards were extensively tested because they frequently gain entry even to modern-style buildings. They are arboreal and nocturnal in habit and have been collected as high as the fourth story of buildings where they congregate after dark to collect the insects attracted to lights. Skinks, on the other hand, seldom climb more than a few feet above the ground and the differences in *Salmonella* carriage rates observed between these two species could well be the result of their preying on different insect species.

A case/control study failed to show any correlation between the presence of household pets and the incidence of salmonellosis in infants and this also suggests that stray and wild animals may be the principal reservoirs of these bacteria on Guam (Haddock and Malilay 1986). Studies elsewhere have shown that farm animals may be infected with *Salmonella* by numerous routes of infection including direct and indirect transmission from wild animals; the epidemiology of salmonellosis in human infants may be less obvious but equally as complex (Haddock 1970; Schnurrenberger et al. 1968; Sodhi and Singh 1970).

Further studies need to be conducted to validate these conclusions, to study in more detail how *Salmonella* enter homes on Guam, and to determine how these bacteria then come in contact with infants. When these points have been clarified, it may be possible to develop effective measures to reduce the incidence of infant salmonellosis on Guam.

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COMPARISON OF THREE MICROBIAL BIOASSAY TECHNIQUES FOR MARINE BACTERIA

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This study evaluates the relative sensitivity, precision, and accuracy of three published microbial bioassay procedures in an attempt to ascertain their ability to detect toxicity potential in the aquatic environments. Three known bioassay methods were compared: the dissolved oxygen depletion (DOD), the viable plate count (VPC), and the optical density (OD). Although both VPC and OD assays showed better reproducibility than the DOD technique, as indicated by lower coefficient of variation (CV) values, the DOD assay proved to be most sensitive and gave end-point reaction at lower concentrations than the VPC and OD methods.

INTRODUCTION

The awareness of assessing the impact of chemical pollutants in the marine environment is a relatively new development in Kuwait. The Arabian Gulf, a semi-enclosed, relatively shallow, small body of water, is considered one of the marine ecosystems whose coastal waters offer a suitable location for investigating the potential impact of toxic chemicals on the marine life.

Since 1977 emphasis on bioassay procedures has increased in support of efforts to monitor and regulate the discharge of pollutants into the environment. Enormous pressure is being put on aquatic toxicologists to provide answers on the potential effects of thousands of chemicals and whether they can be released into the environment (Little 1978).

The need for rapid screening of chemical toxicity has led to the development of a wide range of in vitro bioassays. These assays may help predict toxicity for humans and animals and the effect of chemicals on aquatic organisms representing several trophic levels of these thousands of chemicals entering the environment (Bitton 1983). The ecological effects, which are our main concern, are usually studied to measure the toxicity of chemicals to aquatic organisms representing the different trophic levels of the food chain. Such tests could help estimate the chemical toxicity in natural and man-modified ecosystems.

Bacteria can be suitable bioassay tools because they are inexpensive to cultivate, grow rapidly, and contain enzymatic and physiological processes also found in higher organisms (Bauer et al. 1981; Trevors 1982). Short-term microbial bioassays have been developed to identify toxic pollutants in the environment. Most of these tests are technically simple, rapid, require little space compared with fish bioassays, and are usually an inexpensive approach (Bauer et al. 1981; Liu 1981; Wecher and Stanley 1982). They provide useful and rapid screening tools to aquatic toxicologists, sanitary and environmental engineers, and microbial ecologists. Since bacteria respond more quickly than most other organisms to changes in their environment, they should be sensitive to chemical toxicity (Trevors 1982). Therefore, it was our intention to initiate toxicity studies in Kuwait and to adapt a sensitive, reliable, simple and short-term toxicity assay for predicting the effect of toxic pollutants on the marine ecosystem.

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For this purpose, three toxicity assays were studied: the dissolved oxygen depletion (DOD), the viable plate count (VPC), and the optical density (OD) methods.

MATERIAL AND METHODS

Organisms and growth

Local marine bacteria from Kuwait seawater were used. Aliquots of 100 mL seawater were filtered through 0.45 μm porosity membrane filters. Filters were then transferred onto marine agar plates and incubated at 27°C for 18 hours. After the incubation period, the filters were transferred into a 250 mL flask containing 150 mL nutrient broth and supplemented with 0.5% NaCl. After overnight incubation on a rotary shaker at 27°C, 0.1 mL of the culture was transferred into another flask containing fresh medium. The transfer was repeated for two weeks so that an active, stabilized, mixed master culture was established. From this master culture, other cultures were prepared according to experimental design by adding 100 mL aliquots of the master culture to each 600 mL of nutrient broth containing 0.5% NaCl and incubating them at 200 rpm in a shaker incubator for 18 hours at 27°C.

Chemicals tested

Pollutants tested include one organic polycyclic chlorinated pesticide widely used in Kuwait (BHC lindane, analytical grade), one heavy metal (mercuric chloride, analytical grade), and a wastewater effluent sample from a storm drainage outfall, highly polluted with sewage and industrial waste.

Toxicity tests

Three bacterial bioassay procedures were used in an attempt to assess the toxicity of environmental pollutants.

The DOD technique followed the procedure outlined by Bauer (1981): the 10-fold diluted culture typically gave an optical density of 0.18 to 0.20 at 600 nm. One-hundred mL portions of nutrient broth cultures were added to 600 mL of seawater in which the test chemicals were dissolved prior to the addition of the culture. Three hundred mL portions were removed from the experimental and control flasks, shaken vigorously for 1 min in 1 L plastic bottles, poured into 300 mL BOD bottles and immersed into a 27°C waterbath. Dissolved oxygen was monitored every 2 min with YSI models 51B and 57B oxygen meters, each fitted with a model 5720A self-steering BOD bottle probe. DO readings were recorded until the occurrence of a 50% reduction in the initial DO level and until at least 10 readings were recorded from the experimental bottle. The following modifications were made to Bauer's method: (1) mixed marine bacteria isolated from the Kuwaiti Bay were used instead of activated sludge; (2) cultures were incubated at 27°C rather than 25°C; and (3) the standard buffer was replaced by seawater.

The VPC method described by Anderson and Abdelghani (1980): mixed culture of marine bacteria was grown in nutrient broth containing 0.5% sodium chloride (NaCl) for 18 h prior to inoculation. The test broth media contained nutrient broth and concentrations of the chemicals. Test compounds were sterilized by filtration through 0.45 μm filters and added aseptically to autoclaved nutrient broth containing 0.5% NaCl. One tenth of a milliliter of 18-hour bacterial culture was then added to 100 mL aliquots of the test media at each chemical concentration. Test flasks were incubated aerobically in a shaker at 27°C for 22 h. Non-challenged control cultures were grown in a similar manner. After incubation, numbers of viable cells were determined using the standard plate count technique. All studies were done in triplicate. The following modifications were made to the method: (1) unidentified, mixed, local marine bacteria were used; (2) cultures were incubated at 27°C for 22 h and not at 25°C for 24 h; and (3) seawater was used in comparison with nutrient broth supplemented by 0.5% NaCl for assay purposes.

The OD method was performed by the procedure detailed by Alsop et al. (1980): mixed culture of marine bacteria was grown in nutrient broth containing 0.5% NaCl for 18 hours prior to inoculation. The test material was evaluated at several concentrations in nutrient broth or seawater. Aliquots of 0.1 mL of the culture was added to 250 mL narrow neck flasks containing 100 mL of sterile nutrient broth, 0.5% NaCl, and the test chemical at each concentration. Non-challenged control cultures were treated in a similar manner. Control and test flasks were incubated in a shaker incubator at 27°C for 18 h. After incubation, turbidity values were measured at 600 nm. All tests concentrations were prepared in triplicate.

Statistical treatment

In an attempt to determine the precision and reproducibility of various assay techniques used to conduct the studies presented, both standard deviation and coefficient of variation (relative standard deviation) were determined (Tietz 1976). Comparisons of similar data can be made directly comparing their

means and standard deviations. To compare different data sets, however, it is recommended to calculate the coefficient of variation (CV). The CV provides a measure of relative variability and is calculated as:

$$CV = \frac{S}{X} \times 100$$

where S is the standard deviation and X is the average mean.

Finally the new multiple range test (Duncan 1955) was used to determine significance among means (LC_{50} is the chemical concentration that causes a 50% inhibition of the growth of the bacterial population; or IC_{50}, the chemical concentration that yields an optical density 50% less than the control) obtained using VPC and OD with different growth media (nutrient broth and seawater).

RESULTS AND DISCUSSION

The bioassay described by Bauer et al. (1981) meets the criteria for measuring toxicity and provides a useful format for data presentation and interpretation. In the DOD assay, the control system exhibits an activity that is directly compared to that given by the experimental system. The DOD assay identified the toxicity of three pollutants. All pollutants induced detectable and statistically significant inhibition of DOD in both short-term (brief) and extended exposures. An extreme inhibitory response was elicited by mercury at 2.0 µg/mL in both brief and extended exposures. The addition of 0.15 - 0.20 µg/mL gave moderate response at the brief exposure stage, but induced extreme inhibitory effect after 22 h of incubation (Table 1). In the case of lindane, however,

Table 1. Effects of pollutants on marine bacteria and reproducibility of data obtained after brief and extended exposure assays using the dissolved oxygen depletion method.

Pollutant concentration	Average A.Q B	Average A.Q EX	sd B	sd EX	CV B	CV EX	Effect* B	Effect* EX
Mercury (µg/mL)								
0.02	0.97	0.93	±0.05	±0.06	5.15	6.45	NE	S
0.05	0.91	0.62	±0.05	±0.02	5.49	3.22	S	M
0.10	0.87	0.51	±0.02	±0.12	2.29	23.52	S	M
0.15	0.79	0.42	±0.03	±0.06	3.79	14.28	M	E
0.20	0.69	0.39	±0.10	±0.05	14.49	12.82	M	E
Lindane (µg/mL)								
0.004	0.95	0.95	±0.03	±0.03	3.15	3.15	NE	NE
0.008	0.91	0.00	±0.04	±0.00	4.39	0.00	S	NE
0.010	0.83	0.87	±0.06	±0.05	7.22	5.75	S	S
0.050	0.79	0.81	±0.04	±0.07	5.06	8.64	M	S
0.100	0.74	0.79	±0.05	±0.04	6.76	5.06	M	M
5.000	0.75	0.59	±0.00	±0.03	0.00	5.08	M	M
Wastewater (mL)								
1.00	0.97	0.91	±0.01	±0.01	1.03	1.09	NE	S
10.00	0.80	0.78	±0.02	±0.01	2.50	1.28	S	M
50.00	0.79	0.73	±0.02	±0.03	2.53	4.11	M	M
100.00	0.75	0.66	±0.02	±0.02	2.67	3.03	M	M

A.Q: Activity Quotient
n : No. of Experiments
sd : Standard Deviation
CV : Coeffecient Variation
B : Brief
EX : Extended
NE : No Effect
S : Slight
M : Moderate
E : Extreme

* Effect
>1.05 = Stimulatory
1.0 = No Effect
0.94-0.8= Slight
0.79-0.5= Moderate
<0.49 = Extreme

an extreme effect was not obtained even at the highest concentration tested (5.0 µg/mL).

The wastewater sample tested exhibited a slight toxicity effect at an inclusion level as low as 1 mL (Table 1). This fact is supported by a previous study (EES and FR Divisions 1985) in which the same wastewater stream (same source) was tested. High values of H_2S, oil concentration, and heavy metals

Table 2. The effect of using different analytical techniques and two types of growth media on the determination of LC_{50}/IC_{50} of marine bacteria when exposed to three types of environmental toxicants.

Technique	LC_{50}/IC_{50} (µg/mL)		
	Lindane	$HgCl_2$	Wastewater
Viable plate count			
* seawater	9.1[b]	0.204[a]	47.89[a]
* nutrient broth	8.6[b]	0.17[a]	48.53[a]
Optical density			
* seawater	ND	0.21[a]	57.17[b]
* nutrient broth	10.0[a]	0.29[b]	53.57[b]

ND: Not detected

Note: Values with different superscripts (a or b) are significantly different at $P < 0.05$ level.

Table 3. Sensitivity of three toxicity screening procedures to different chemicals.

Chemical	Concentration that gives end-point reaction to toxicants (µg/mL)					
	15-20 min DOD	18-22 h DOD	18-22 h TM		18-22 h VM	
			SW	NB	SW	NB
Lindane	S:0.01 M:0.05-5.0	S:0.01 M:0.1-5.0	-	10.00[b]	9.1	8.6
$HgCL_2$	S:0.05 M:0.15 E: >0.20	S:0.02[a] M:0.1 E:0.15	0.21	0.29[b]	0.20	0.17
Sewage	S:10 mL M:50-100 mL E: >100 mL	S:1 mL[a] M:10-100 mL E: >100 mL	57.17 mL[b]	53.57 mL	47.89 mL	48.53 mL

a most sensitive
b most resistant
S: Slightly toxic
NB: Nutrient broth
PC: Plate count
M: Moderately toxic
E: Extremely toxic
SW: Seawater
OD: Optical density

(Ni, Co, Vn) were detected. These values are higher than the proposed effluent criteria. This proves that the sample tested represents a mixture of environmental pollutants. Thus, the toxicity of the tested wastewater could be attributed to any of these pollutants or to their synergistic effects.

Measurements of turbidity (Alsop et al. 1980) and chemical inhibition of viable cells using agar plates (Liu and Kwasniewska 1981; Albright et al. 1972) for indicating growth and inhibition of microorganisms were documented in toxicity research. However, many investigators have repeatedly shown that several pollutants are toxic to aquatic microbes when present in rather low concentrations, and assays such as those that determine sub-lethal effects of chemical pollutants would be important, e.g., the DOD technique (Albright et al. 1972).

Table 2 shows that the VPC method showed better sensitivity than the OD technique. However, mercury in the LC_{50} and IC_{50} data shows more toxicity than lindane. Also seawater (as a medium) is statistically as good as nutrient broth in both VPC and OD assays.

The possible precipitation occurring from reactions between the test material and growth medium is one of the limitations of the OD method (Alsop et al. 1980). We faced such a problem when testing the toxicity of lindane in seawater, which proved to react with the seawater.

The DOD technique always gives end-point reaction at lower concentrations (in both brief and extended exposure) than the VPC and OD methods (Table 3). The DOD technique has the advantage of being able to detect three ranges of toxicity: slight, moderate, and extreme. The moderate range of toxic-

Table 4. The reproducibility of data obtained after 22 h exposure of mixed marine bacteria to chemicals using viability method.

Chemical	Medium	Average LC_{50} µg/mL	sd	CV
Mercury	NB	0.17	± 0.01	10.90
	SW	0.20	± 0.02	9.80
Lindane	NB	8.60	±0.12	1.46
	SW	9.10	±0.20	2.30
Wastewater	NB	48.53	±1.59	3.27
	SW	47.89	±1.99	4.15

sd: Standard deviation SW: Seawater
CV: Coeffecient of variation NB: Nutrient Broth

Table 5. The reproducibility of data obtained after 22 h exposure of mixed marine bacteria to chemicals using turbidity method.

Chemical	Medium	Average LC_{50} µg/mL	sd	CV
Mercury	NB	0.29	± 0.01	3.10
	SW	0.21	± 0.02	11.22
Lindane	NB	10.00	± 0.40	4.00
	SW	NM	-	-
Wastewater	NB	53.57	± 1.40	2.61
	SW	57.17	± 2.78	4.86

sd: Standard Deviation SW: Seawater
CV: Coeffecient of variation NB: Nutrient Broth
NM: Not measured

ity is comparable to the LC_{50} values obtained by the other two techniques (Table 3). Sensitivity of the VPC method in toxicity screening of the three pollutants tested proved to be better than that of the OD method (lower LC_{50} values were always obtained).

The initial screening assays should be inexpensive, rapid, repeatable, and sensitive enough to detect toxicity from a broad range of different chemical pollutants (Busch 1982; Bauer et al. 1981). The three bacterial bioassays described in this study seem to have the potential of fulfilling these criteria. Although both OD and VPC assays showed better reproducibility than the DOD technique, as indicated by lower CV values (Tables 4 and 5), yet the DOD assay proved to be the most sensitive.

CONCLUSION

The three bacterial bioassay techniques tested in this study prove to be rapid, repeatable, inexpensive, and sensitive. However, by detecting three ranges of toxicity, the DOD assay indicated a higher sensitivity than the others. The responses of the DO depletion rate varied according to chemical concentration. A decrease in concentration of chemical resulted in decreased inhibition in the DO depletion. Finally within the toxicity effect of chemicals on marine bacteria, mercury was found more toxic than lindane.

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SILICA AND ALUMINUM IN THE LUNGS OF FERAL PIGEONS AND EXPERIMENTAL RATS EXPOSED TO STUDDED TIRE-GENERATED ROAD DUST

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Feral pigeons' lungs in Sendai, where particle levels were high in winter due to the use of studded tires for automobiles, and in Tajiri, where air was clean with no noticeable increase in dust level throughout the seasons, were examined for the element levels as indicators of air pollution. Aluminum, Pb, Si, Ti, and possibly Cd levels in the lungs were significantly higher in Sendai pigeons than in their counterparts in Tajiri, and the blood levels of Al, Pb, Si, and Ti were also higher in the former than in the latter. Experimental exposure of rats to dust-loaded outdoor air for a three-month period in the winter season in comparison with exposure to the filtered outdoor air and clean animal room air disclosed that the elevation of Al and Si was observed only in the rats exposed to the dust-loaded air, suggesting the deposit of airborne particles in the lungs.

INTRODUCTION

The general atmosphere becomes quite dusty in December through March in the central part of the city of Sendai in northeastern Japan (Sendai City 1982; Miyagi Prefecture 1984) when the vehicles equipped with studded tires run through dry, asphalt-paved roads where snow covers the ground only occasionally. When studs scratch the pavement of the roads, dust is generated. An epidemiological study (Ikeda et al. 1986a) has disclosed that upper respiratory symptoms such as phlegm, sneezing, nasal flow, and sore throat were more prevalent among Sendai downtown citizens than those in rural areas where the air was clean. Because the concentrations of respirable particles (Ø < 11 μm) were also elevated in addition to total (Ø < 30 μm) airborne particles especially in winter in Sendai (Sendai City 1982), the subsequent concerns were if the smaller-sized particles were inhaled into the lungs and accumulated there during the winter seasons.

The present study was initiated to examine whether the elevated dust exposure is associated with the increases in dust-indicator element levels in the lungs of naturally-exposed feral pigeons or experimentally-exposed rats. Enhanced response of human lungs to SQUID (superconducting quantum interference device) was reported separately by a cooperating group elsewhere (Takishima et al. 1987).

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MATERIALS AND METHODS

Study sites

The central part of Sendai, a prefectural city, was studied in comparison with a rural village, Tajiri. Atop the Miyagi prefecture office building in the center of the city of Sendai, a national air quality monitoring station (Sendai Monitoring Station) was established to observe city air qualities. There was another national monitoring station in the vicinity of Tajiri village (Nonodake Monitoring Station; some 45 km north of Sendai), which was established to

observe background levels of pollutants in clean air. The comparison of the air qualities as monitored at the two stations was detailed in the previous report (Ikeda et al. 1986a). In brief, the annual average particle (Ø < 40 μm) levels at Sendai Station were 28 $\mu g/m^3$) with the highest value for January to February (33 $\mu g/m^3$) and the lowest value for September to October (20 $\mu g/m^3$), whereas it was 14 $\mu g/m^3$ with no change throughout four seasons at Nonodake Station. Dust fall in winter in downtown Sendai recorded well over 100 Mg/km^2·month.

Pigeons and rats

Feral pigeons (*Columba livia* var.), whose lives are protected by law, were captured in the winters of 1984 and 1985 by special permission for scientific research of the Environment Agency, the government of Japan. One group (the exposed group) was captured in Kotodai Park immediately south of the Miyagi prefecture office building (in the center of the city of Sendai).

The other group (the non-exposed group) was caught at rice storehouses in Tajiri village. The pigeons were transferred to the laboratory within 24 hours after trapping and killed under ether anesthesia for collection of blood and lungs.

Male Wistar rats, weighing about 250 g at the beginning of the experiments, were divided into three groups (13 animals per group). Two groups were exposed to outdoor air, either filtered (i.e. particle-removed) or unfiltered (i.e. particle-borne), utilizing the temperature-controlled exposure chambers set on the verge of a heavy traffic road (the chambers were developed by Oka et al. 1982; the air-heating system was fortified to cope with chilly outdoor air in winter in Sendai, colder by about 4°C than that of Osaka where the chambers were originally designed for use). Outdoor air was warmed up to 20 to 22°C by means of a heat exchanger immediately before introduction to Chamber 1 in which one group of the animals (the dust-exposed group) were kept. The outdoor air was not only warmed but also passed through a filter (Cambridge Absolute Filter, 1D-25; Cambridge Filter Japan, Ltd., Tokyo, Japan) to remove airborne particles before it was introduced into Chamber 2 where another group (to be called the gas-exposed group because possible pollutant gas was not removed) was housed. The third group (the non-exposed group) was maintained in an animal room where clean air was supplied. Animals were caged individually and given free access to water and laboratory chow (type F-1; Funabashi Farm, Funabashi, Japan). The exposure to the outdoor air continued 24 hours a day for three months from late December 1984 to late March 1985. At the end of the exposure period, the animals (13 each from the three groups) were sacrificed by bleeding under ether anesthesia for collection of lungs.

Table 1. Analytical conditions of elements.

Method	Element	Wavelength (nm)	Torch height (mm)
ICP[a]	Al	361.160	28
	Ca	317.924	16
	Fe	259.939	16
	Mg	285.215	16
	Si	251.600	20
	Ti	334.939	25
	Zn	213.856	16
FlAA[b]	Cd	228.8	
	Cr	359.3	
	Ni	232.0	
	Pb	283.3	

[a] ICP: Inductively coupled plasma emission spectrophotometry.
[b] FlAA: Flameless atomic absorption spectrophotometry.

Analyses for elements

Tissues were weighed immediately after collection and then kept frozen till analyses. The lungs after thawing were rinsed with redistilled water and freeze-dried for 24 hours to a constant weight prior to the ashing. About 0.15 to 0.25 g dry weight of the lung was wet-ashed by heating in the presence of 1 mL of 61% nitric acid and 0.25 mL of 60% perchloric acid in a micro-Kjeldahl flask, whereas 10 mL of pigeon blood was heated with 10 mL of the nitric acid and 2.5 mL of the perchloric acid in a Kjeldahl flask (Watanabe et al. 1982). The volume of the final digest of the lung and the blood was adjusted to 5 and 50 mL, respectively, by the addition of redistilled water in a screw-capped polypropylene tube, and subjected to element analyses (after further dilution with redistilled water as necessary) under the conditions listed in Table 1. The details of the procedures of analyses by inductively coupled plasma emission spectrophotometry (Ikeda et al. 1986b) and flameless atomic absorption spectrophotometry (Watanabe et al. 1989a and b) were as previously described.

Particle counting

The particle (Ø < 10 μm) concentrations in the air of the two exposure chambers were continuously monitored by use of digital dust indicators (Model AP-632; Shibata Scientific Technology Ltd., Tokyo, Japan). The particle levels are depicted in Fig. 1. The particle levels in the air for the dust-exposed group were in the range of 15-25 $\mu g/m^3$, while the concentrations in the filtered air for the gas-exposed group were in the range of 3-5 $\mu g/m^3$ or about one fifth of that in the unfiltered air.

Statistical analyses

A preliminary analysis disclosed that the levels of some elements (mostly pollutant elements) in the tissue distributed in a wide range with a coefficient of variation of >1 when a normal distribution was assumed, suggesting that the distribution was not normal. Accordingly, both normal and log-normal distributions were assumed from practical viewpoints so that the results of the element analyses were expressed in terms of arithmetic mean ± arithmetic standard deviation (AM±ASD), and also geometric mean and geometric standard deviation [GM(GSD)] for pollutant elements, whereas only AM±ASD were figured out for essential elements. The statistical significance of the difference between means was examined with t-test.

RESULTS

Naturally-exposed feral pigeons

Because of technical reasons, the number of pigeons available annually was limited to 30 birds each in Sendai (the exposed group) and in Tajiri (the non-exposed group). As there was no statistically significant difference ($p > 0.10$) between the results ob-

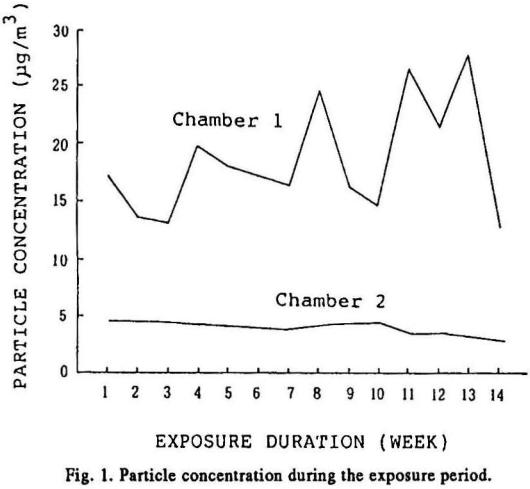

Fig. 1. Particle concentration during the exposure period.

The concentration of particles (Ø < 10 μm) was monitored 24 hours a day for the three-month exposure period from late December 1984 to late March 1985. The lines indicate weekly average concentrations. Chamber 1 (for the dust-exposed group) was supplied with warmed but non-filtered outdoor air, and Chamber 2 (for the gas-exposed group) was supplied with warmed and filtered outdoor air.

Table 2. Element levels in pigeon lungs.

Group	Number of pigeons[a]	AM or GM[b]	Dry lung weight (g)	Element (mg/g dry weight of tissue) Al	Ca	Cd[c]	Cr[c]	Fe	Mg	Ni[c]	Pb[c]	Si	Ti	Zn
Exposed	60	AM ±ASD	0.18 ±0.04	0.16** ±0.16	0.90* ±0.95	0.07 ±0.04	0.86 ±0.80	0.98 ±0.18	0.57 ±0.06	0.41 ±0.46	2.35 ±0.75	0.05 ±0.08	0.008** ±0.008	0.05 ±0.01
		GM (GSD)		0.09** (1.99)	0.74** (1.52)	0.05* (1.55)	0.59* (2.42)			0.24 (3.66)	0.82** (2.60)	0.012** (2.89)	0.005** (1.97)	
Non-exposed	60	AM ±ASD	0.19 ±0.04	0.09 ±0.11	0.60 ±0.31	0.06 ±0.04	0.66 ±0.87	1.01 ±0.55	0.60 ±0.19	0.57 ±0.81	0.42 ±0.28	0.03 ±0.08	0.004 ±0.005	0.05 ±0.01
		GM (GSD)		0.05 (1.97)	0.55 (1.29)	0.05 (1.65)	0.39 (2.61)			0.25 (5.10)	0.34 (1.55)	0.007 (2.89)	0.002 (2.07)	

Both AM±ASD and GM(GSD) are calculated for pollutant elements whereas only AM±ASD are figured out for essential elements, except for Ca for which both are given because ASD/AM is large. Asterisks indicate that the difference from the non-exposed group is statistically significant (** for $p<0.01$, * for $p<0.05$).

[a] Pigeons captured in 1984 and 1985 are combined.
[b] With an assumption of either a normal distribution or a log-normal distribution.
[c] μg/g dry weight of tissue.

Table 3. Element levels in pigeon blood.

Group	Number of pigeons[a]	AM or GM[b]	Element Al (mg/L)	Cd (μg/L)	Pb (μg/L)	Si (mg/L)	Ti (μg/L)
Exposed	60	AM ±ASD	0.81** ±1.08	1.51 ±0.88	142.1 ±301.9	5.14* ±7.94	51* ±55
		GM (GSD)	0.54** (2.23)	1.32 (1.70)	92.7** (2.07)	2.91** (2.58)	38** (2.02)
Non-exposed	60	AM ±ASD	0.40 ±0.36	1.63 ±0.94	67.8 ±70.5	2.52 ±2.70	30 ±44
		GM (GSD)	0.32 (1.87)	1.42 (1.68)	46.0 (2.31)	1.89 (2.03)	20 (2.58)

Asterisks indicate that the difference from the non-exposed group is statistically significant (** for $p<0.01$, * for p).

[a] Pigeons captured in 1984 and 1985 were combined.
[b] With an assumption of either a normal distribution or a log-normal distribution.

tained in 1984 and 1985, the two-year results were pooled for statistical evaluation (Table 2) so that both the exposed group and the non-exposed group consisted of 60 birds, respectively. The analyses for the ten elements disclosed that the levels of Al, Ca, and Ti in the lungs were significantly higher ($p < 0.05$) in the exposed group than in the non-exposed group. The elevation in Cd, Pb, and Si in the exposed group was also statistically significant ($p < 0.05$) when a log-normal distribution was assumed, although GSD was >2 in the cases of Si in both groups and Pb in the exposed group. The levels of Fe, Mg, P, and Zn were essentially comparable between the two groups. When the levels of Al, Cd, Pb, and Si in blood were compared between the two groups, Al, Pb, Si, and Ti levels were significantly ($p < 0.01$) higher in the exposed group than in the non-exposed group, whereas there was no significant difference ($p > 0.10$) in Cd levels (Table 3).

Rats experimentally exposed to particle-borne roadside air

In order to examine if the elevation in the levels of some elements in the dust-exposed pigeons was associated with the inhalation of particles, the element levels in the lungs of rats exposed to particle-borne roadside air for three months (the dust-exposed group) were compared with the levels in those exposed to the air after filtration to remove the particles (the gas-exposed). The comparison was also made with the levels in those kept in clear air (the non-exposed group). It is evident from the comparison (Table 4) that both Al and Si levels in the lungs were significantly ($p < 0.01$) higher in the dust-exposed group than the counterpart levels in both the gas-exposed rats and the non-exposed rats. Because there was no significant ($p > 0.10$) difference in the Al and Si levels between the gas-exposed and the non-exposed groups, the increase in Al and Si in the dust-exposed group should be attributable to the exposure to the dust and not to the unfilterable gas.

Table 4. Element levels in rat lungs.

Group	Number of rats[a]	AM or GM[b]	Element (μg/g dry weight of tissue)							
			Al	Ca	Cd[c]	Fe	Mg	Pb[c]	Si	Zn
Dust-exposed	13	AM ±ASD	5.2 ±1.0	577 ±130	14 ±7	340 ±62	485 ±44	88 ±64	3.1 ±1.6	66 ±6
		GM (GSD)	5.1 (1.14)		14 (1.51)			66 (2.38)	2.7 (1.41)	
Gas-exposed	13	AM ±ASD	3.0** ±1.3	638 ±122	8 ±5	366 ±27	504 ±19	75 ±64	1.9* ±1.3	68 ±2
		GM (GSD)	2.8** (1.28)		6 (2.02)			53 (2.61)	1.5* (1.57)	
Non-exposed	13	AM ±ASD	2.8** ±0.6	708 ±312	11 ±5	352 ±44	506 ±34	81 ±153	1.5** ±0.5	68 ±5
		GM (GSD)	2.8** (1.05)		0.020 (1.60)			33 (3.44)	1.4** (1.28)	

Both AM±ASD and GM(GSD) are calculated for pollutant elements whereas only AM±ASD are figured out for essential elements. Asterisks indicate that the difference from the dust-exposed group is statistically significant (** for $p < 0.01$, * for $p < 0.05$).

[a] Rats exposed in 1985 were examined.
[b] With assumption of either a normal distribution or a log-normal distribution.
[c] ng/g dry weight of tissue.

DISCUSSION

The present study of the feral pigeons exposed to airborne particles through their life in an urban environment disclosed that their lungs contain more Al, Ca, Pb, Si, Ti (and possibly Cd also) than the lungs of their counterparts in a clean atmosphere (Table 2). Al, Pb, and Si levels in the blood were also higher in the former group than the latter (Table 3). Furthermore, continuous exposure of experimental rats to particle-borne urban outdoor air for three months resulted in the particle-associated elevation of Al and Si levels in the lungs.

Monitoring of environmental pollutants by means of analyses of biological specimens for pollutant elements has been conducted using both animals and plants, and feral pigeons were especially evaluated as a sensor of air pollution (Tansy and Roth 1970; Ohi et al. 1974). For example, Ohi et al. (1974 and 1981) observed that the Pb levels together with delta-aminolevulinic acid dehydratase activities in pigeon blood reflected not only intensity of regional atmospheric lead pollution but its amelioration in Tokyo in the 1970s. According to Ito (1981), the contents of pollutant metals, especially Pb, were closely related to the extent of dust deposit (taken as an indicator of air pollution) in human autopsy lung specimens. Association of pollutant element contents with dust deposit was also found in the lungs of dogs in industrialized areas in Japan (Kawai 1983). In the cases of plants, Ho and Tai (1985) found that Pb and other metals in roadside ferns significantly related with traffic burden of the roads. Similarly, Falahi-Ardakani (1984) disclosed that the levels of Cd, Ni, Pb, and Zn in grass alongside U.S. Highway 1 in Beltsville, MD, were reversely related to the distance from the highway. Concerns, however, were focused in most reports to Pb discharged from automobiles, and little attention has been paid to other elements such as Al or Si.

Regarding the sources of these elements, it is known (e.g. Mizohata and Mamuro 1980) that Al in urban air particles originates from soil. In close association with the present study, Takahashi et al. (1981) collected airborne particles (Ø < 30μm) on the edge of heavy traffic roads in downtown Sendai once in March and then in June when the air was most dusty and relatively clean, respectively, and compared the metal contents in terms of equal volumes of sample air. It was found that the levels of Al, Ca, and Fe, in March air (34.20, 168.85, 44.78 μm^3 air, respectively) were 3 to 10 times higher than the levels in June, and Pb and Zn levels in March (0.62 and 1.60 $\mu g/m^3$ air, respectively) were also elevated by 1.7 and 1.3 times over the March levels. Analyses of winter roadside dust in Sendai revealed that the dust contained as much as 15% quartz and that silica contents were as high as 56% (Ikeda et al. 1986b), on line with the fact that gravel has been commonly used as aggregate in asphalt pavement and would be pulverized during the course of damage of the roads in winter. It is also known that the white paint applied on the road surface for indication of traffic regulation such as lanes and zebra zones contains appreciable amounts of Ca (e.g. about 25%: Takahashi et al. 1981; and yellow paint also contains Ca (30%) in addition to Pb (0.4%) and Cr (0.1%) (Mohri et al. 1983). Of particular interest is the elevated Ti content in urban pigeon lung tissues, as Mohri et al. (1983) found that the studs in tires contain Ti by 1-4% depending on the model of the studded tires. This element, Ti, was however detectable at levels of up to 320 ng/m^3 in the atmosphere of industrial areas in Japan (Mamuro and Mizohata 1978) where no studded tires would be used, and therefore studs would not be the sole source of Ti in the pigeon lungs.

Comments will be necessary for the possible source of Pb in the pigeon lungs. Kotodai Park (about 26 320 m^2 in space), located adjacent to a cross of two avenues where the traffic is heavy, has surface soil polluted by Pb (up to 696 mg/kg) presumably derived from automobile exhaust at the time when gasoline was still leaded (Seki et al. 1970-71). It was reported that pigeons have the habit of ingesting sand, even if coated with lead, for gizzard gravel (Ohi et al. 1974). Thus, it is possible that the elevated Pb levels in the lungs and blood of the exposed pigeons were at least partly due to Pb-polluted soil of the park where they lived. The difference in the findings that Pb in the lungs was elevated only in the exposed pigeons and not in the dust-exposed rats is apparently on line with the Pb intake via polluted soil in the park, because the rats had no contact with the Pb-contaminated soil although they were exposed to the air contaminated with automobile exhaust.

In conclusion, the elevated levels of Al, Si, and other elements in the lungs of pigeons and rats exposed to studded tire-generated road dust appear to be best explained as the result of accumulation of the dust particles in the lungs through the respiration of the particle-borne air in winter.

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TRACE METALS IN BIVALVES AND SEDIMENTS FROM TOLO HARBOUR, HONG KONG

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Concentrations of iron, copper, zinc, cadmium, and lead were determined in samples of sediment, mussel (*Perna viridis*), and rock oyster (*Saccostrea cucullata*) from nine locations in Tolo Harbour, Hong Kong. The concentrations of metals in bivalves did not vary greatly from one location to another and showed no correlation with the concentrations in sediments. The metal concentrations in bivalves are similar to published results in the same area, and concentrations of cadmium and lead are within the local legislative limits for seafoods. Comparison of metal concentrations in bivalves in March and May 1986 shows that lower concentrations of iron, copper, and cadmium in *P. viridis* occurred in May, suggesting seasonal variation of trace metal concentrations in mussels. This reduction was not evident in *S. cucullata*.

INTRODUCTION

The coastal waters in Hong Kong are grossly polluted with domestic, agricultural, and industrial wastes (Morton 1976). The pollution problem in Tolo Harbour in the northeastern part of Hong Kong has recently attracted much public attention. The Harbour is almost completely landlocked with only a narrow inlet (Fig. 1), thus forming a natural settling basin for wastes discharged to the Harbour. Construction of the Plover Cove Reservoir and large-scale land reclamation in Sha Tin further limit the exchange of water through tides or currents. Input of pollutants to the Harbour has increased due to urban and industrial development in Sha Tin and Tai Po, including the operation of sewage treatment plants. Pollution monitoring programmes are necessary as fish and shellfish in the Harbour are harvested for human consumption and specific areas are designated for fish culture in floating cages as well as utilized for other maricultural practices.

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Studies of inorganic nutrients and coliform bacteria have shown that Tolo Harbour is significantly polluted (Trott and Fung 1973; Kueh 1974; Wear et al. 1984). Metal contamination in sediments and biota from the iron ore tailings in Ma On Shan has also been studied (Wong and Li 1977; Wong and Tam 1977; Wong et al. 1978, 1979). The present paper reports the concentrations of several trace metals in sediments and two common bivalves from the Harbour. The species studied are the mussel *Perna viridis* (L.) and the rock oyster *Saccostrea cucullata* (Born; synonym: *S. glomerata*, among other nomenclature; see Morris 1985). The use of bivalves to monitor marine pollution by conservative contaminants has been recommended by many authors (e.g. Goldberg 1975; Phillips 1977). The suitability of the two bivalves as indicators of the degree of trace metal pollution has been evaluated in Hong Kong waters by Phillips (1979, 1985). The metal concentrations found in the two edible molluscs can also be used to establish whether contamination is within levels acceptable for consumption.

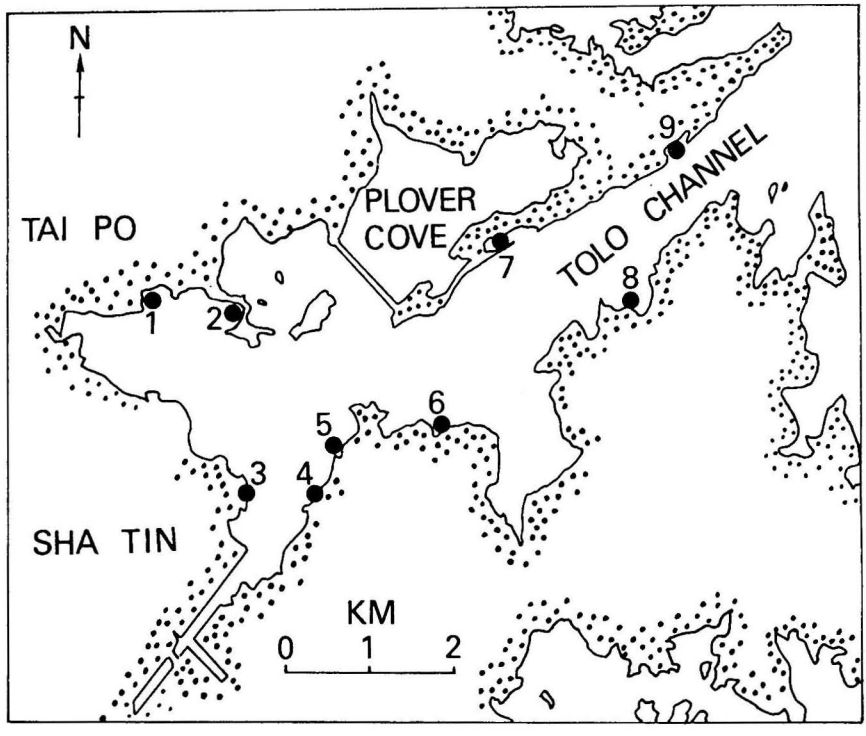

Fig. 1. Sampling sites for sediments and bivalves in Tolo Harbour. 1, Tai Po Industrial Estate; 2, Sam Mun Tsai; 3, Ma Liu Shui; 4, Ma On Shan; 5, Wu Kai Sha; 6, Nai Chung; 7, Lo Fu Wat; 8, Lai Chi Chong; 9, Fung Wong Wat.

MATERIALS AND METHODS

Sampling

Samples of *Perna viridis*, *Saccostrea cucullata*, and sediment were collected from nine locations in Tolo Harbour on March 26, 1986 (Fig. 1), although not both species were present at each site (see Results). A similar sampling was carried out on May 5, 1986. All samples were frozen until analysis.

Analysis

The concentrations of iron, zinc, copper, cadmium, and lead in samples were determined according to the method described by Allen et al. (1974). Bivalves were first thawed and dissected, and then the soft tissues were dried at 105°C for 24 h, weighed, and powdered. Sediment samples were air-dried for a week and then passed through a 2 mm mesh sieve. Samples of bivalves and sediment were then digested with the acid mixture of 60% $HClO_4$ (154 mL/L), 70% HNO_3 (769 mL/L) and 95% H_2SO_4 (77 mL/L). The levels of trace metals were analyzed with flamed atomic absorption spectrophotometry using a Varian AA-1475 instrument.

Data analysis

Mean values of dry weight and metal concentration of samples from different sites were compared using one way analysis of variance followed by Tukey test (Zar 1984). Correlation between values in sediments and bivalves was determined by estimating the correlation coefficient. Values obtained in the two surveys were compared using Student's t-test. Significant difference was assumed at a probability level of 0.05.

RESULTS

Concentrations of iron, zinc, copper, and cadmium in sediments, *Perna viridis*, and *Saccostrea cucullata* collected on March 26, 1986 are shown in Fig. 2. It appears that higher concentrations of metals, especially iron and zinc, were found in sediments from inner Tolo Harbour than in sediments from the

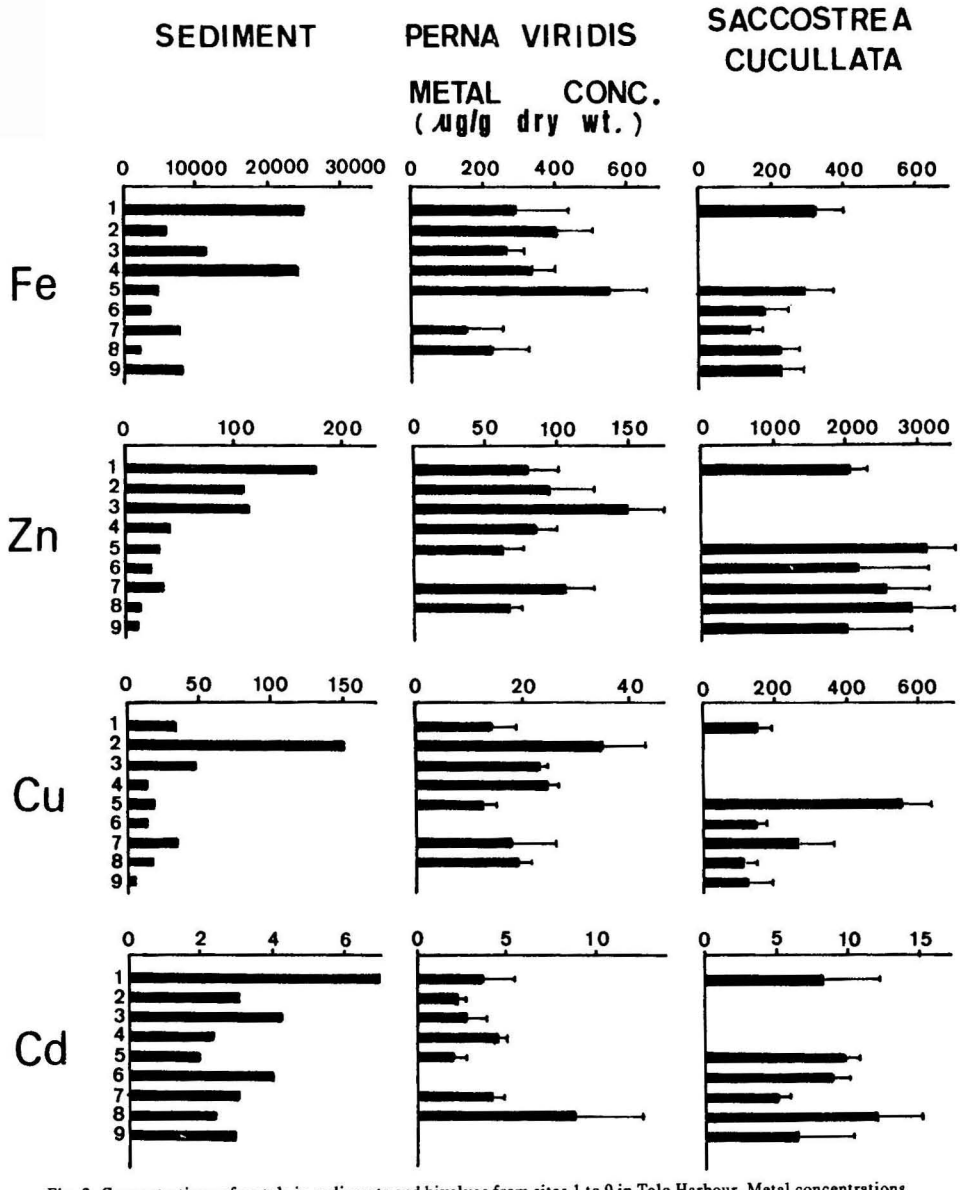

Fig. 2. Concentrations of metals in sediments and bivalves from sites 1 to 9 in Tolo Harbour. Metal concentrations in sediments are means of triplicate determinations on a single sample. Metal concentrations in bivalves are means of six to eight individuals. Error bars represent one standard deviation. All samples were collected on Mar. 26, 1986.

Tolo Channel. The two bivalves accumulated different amounts of metals in their tissues, but there were no obvious differences between the metal concentrations in *P. viridis* or *S. cucullata* from the various sites. Comparison of the dry weight of *P. viridis* shows that mussels from Sites 5 and 8 are significantly different in weight from those from other sites" (see Table 1 for dry weight values). Since the concentration of trace metals in bivalves is dependent on individual size (Boyden 1974), the values of metal concentration in mussels from the two sites were excluded from subsequent analysis. The metal

Table 1. Metal concentration and dry weight of *Perna viridis* and *Saccostrea cucullata* collected from Tolo Harbour. Values are means ± standard deviations (N = no. of individuals) The upper number gives the value for specimens collected on March 26, 1986 and the lower number the value for those collected on May 5, 1986.

Site	N	Dry weight (g)	Metal concentration (μg/g dry wt)			
			Fe	Zn	Cu	Cd
			Pema viridis			
2	8	1.06 ± 0.40	406 ± 100	94 ± 34	35.1 ± 7.8	2.3 ± 0.5
	7	1.26 ± 0.47	179 ± 64 **	78 ± 32	19.9 ± 5.1 **	0.8 ± 1.1 **
3	6	0.98 ± 0.14	264 ± 52	150 ± 25	22.9 ± 1.6	2.9 ± 1.0
	8	1.03 ± 0.24	115 ± 25 **	87 ± 16 **	16.0 ± 2.3 **	1.3 ± 0.5 **
4	7	0.83 ± 0.18	336 ± 64	85 ± 15	24.7 ± 1.7	4.5 ± 0.5
	8	0.48 ± 0.07 **	182 ± 47 **	87 ± 14	16.1 ± 2.0 **	2.0 ± 1.2 **
5	8	1.52 ± 0.25	556 ± 92	63 ± 14 *	12.6 ± 2.6 **	2.1 ± 0.7
	7	0.51 ± 0.18 **	281 ± 85 **	91 ± 22	18.8 ± 1.7	1.0 ± 0.8 **
7	8	0.88 ± 0.25	177 ± 80	105 ± 21	17.8 ± 8.0	4.2 ± 0.7
	8	1.08 ± 0.35	206 ± 37	94 ± 31	9.4 ± 2.0 **	0.6 ± 0.7 **
8	8	0.38 ± 0.12 **	225 ± 103	67 ± 9	19.2 ± 2.5	8.9 ± 3.7
	8	0.60 ± 0.18	172 ± 40	77 ± 15	11.0 ± 2.1 **	3.1 ± 0.9 **
			Saccostra cucullata			
5	6	0.18 ± 0.05 *	290 ± 83	3275 ± 826	556 ± 77	9.8 ± 1.0
	6	0.36 ± 0.17	350 ± 109	2863 ± 732	455 ± 162	3.2 ± 1.4 **
6	6	0.22 ± 0.14	180 ± 64	2373 ± 952	149 ± 27 **	9.0 ± 0.1
	7	0.21 ± 0.04	216 ± 53	2476 ± 267	229 ± 53	4.0 ± 1.8 **
9	6	0.34 ± 0.15 **	228 ± 62 *	2082 ± 803	125 ± 73	6.5 ± 3.8
	8	0.77 ± 0.20	327 ± 96	2210 ± 661	149 ± 36	7.0 ± 1.3

* Significantly smaller value of the pair; $0.01 < P < 0.05$
** Significantly smaller value of the pair; $P < 0.01$

concentrations in mussels from the other sites are not significantly different from one another. Further, there are no significant differences between body weight nor metal concentration in studied *S. cucullata*. An estimate of correlation coefficients illustrates no correlation between the metal concentrations in sediments and the bivalves. Concentrations of lead were below 5 μg/g dry weight for all bivalve and sediment samples. Since this value is close to the detection limit of our methodology, the levels for individual sites are not presented.

A comparison of metal concentrations in bivalves collected in March and May is shown in Table 1. Despite the differences in some cases, in dry weight of *P. viridis*, it is apparent that concentrations of iron, copper, and cadmium were lower in mussels collected in May. In contrast, there appears to be little differences in metal concentrations between *S. cucullata* in March and May.

DISCUSSION

Concentrations of trace metals in sediments and bivalves reported in the present study are comparable to published data from less extensive surveys in Tolo Harbour (Phillips and Yim 1981; Phillips 1979, 1985). An exception is that cadmium concentrations in *Perna viridis* found in this study are considerably higher. This discrepancy, however, may partially result from seasonal variation of metal concentrations in mussels. The present study shows that concentra-

tions of iron, copper, and cadmium in *P. viridis* are higher in March than in May. A decrease in metal concentrations from spring to summer has been reported in other mytilids such as *Mytilus edulis* (e.g. Amiard et al. 1986). Further, Phillips and Yim (1981) showed a decrease in concentrations of iron and copper but an increase in zinc concentration in the mussel *Septifer virgatus* from Hong Kong waters in the period from March/April to August. Seasonal fluctuations of metal concentrations in bivalves are often attributed to a change in water content, which is in turn influenced by factors such as food availability, physiological state, and sexual maturity (see Phillips 1977 for review). This reasoning may apply in the present study as ripe gonads present in most mussels collected in March were not observed in May, suggesting that spawning and associated changes in body constituents may have occurred during this period of time. The lack of variation in zinc concentration between mussels from the two surveys may be due to metabolic regulation of zinc by this bivalve (Phillips 1985). The elucidation of relationship between body composition, sexual maturity, and trace metal concentration in bivalves awaits further studies.

An objective of this study was to determine whether trace metal concentrations in bivalves are too high for human consumption. The maximum permitted concentration of cadmium and lead present in seafoods as set by the Hong Kong Government is 2 and 6 μg/g live weight, respectively. The concentrations of these two metals in mussels and rock oysters found in this study, converted to a wet weight basis, do not exceed these acceptable limits. Copper, iron, and zinc in seafoods are not subject to control by local legislation.

The present study shows that metal concentrations in sediments from Tolo Channel are generally lower than those from inner Tolo Harbour adjacent to the towns of Sha Tin and Tai Po, indicating arthrogenic input of trace metals. The concentrations in bivalves, however, do not exhibit this trend but suggest roughly similar biological availability of metals in the whole area. Elevated levels of some metals in specific sites may be due to localized sources of metals. High copper concentration in sediments and mussels from Sam Mun Tsai (Site 2) probably results from uptake of this metal from anti-fouling paints put on vessels in this fishing village. Davies and Paul (1986) reported that copper is accumulated from anti-fouling compounds by the scallop, *Pecten maximus*, and the Pacific oyster, *Crassostrea gigas*. In addition, copper sulphate, extensively used to treat diseases in fishes cultured in floating cages, may also contribute to the high copper concentration observed in this area.

Elevated cadmium concentration was noted in *Perna viridis*, and possibly also *S. cucullata* from Lai Chi Chong (Site 8). A comparatively high cadmium concentration in *P. viridis* from the same site was also indicated by Phillips (1985). Phillips (1979) suggested that cadmium leached from black shale may account for the increased concentrations of this metal in *S. cucullata* from Tolo Channel.

Previous studies have demonstrated metal contamination by iron ore tailings in sediments and biota in Ma On Shan (Site 4) (Wong and Li 1977; Wong and Tam 1977; Wong et al. 1978, 1979). The present study, however, shows that elevated iron level in sediment from this site was not accompanied by increased metal concentrations in mussels. Recent land reclamation in this area might have reduced the biological availability of the metals.

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INVESTIGATION OF INDOOR THERMAL ENVIRONMENT, AIR QUALITY, AND ENERGY CONSUMPTION IN NEW DETACHED HOUSES OF WOOD-FRAME CONSTRUCTION IN A SMALL CITY IN JAPAN

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The authors investigated indoor thermal environment, airtightness, indoor air quality, and energy consumption in thirteen new houses of wood-frame construction in a local city of Japan in the winter of 1985. All houses had thermally-insulated walls, ceilings, and floors, except for one house which had a concrete floor without insulation under the floor. Eight houses had concrete floors on the first level of the structure. Seven houses out of eight had hot-water pipes embedded in the concrete for floor heating and thermal insulation under the floor on the grade. Three houses out of seven also had fan coil units in the bedrooms on the second floor. The six other houses without floor heating had oil or gas local space heaters. The authors found differences in temperature profiles between the houses with floor heating and those with space heaters. The effective leakage area per floor area obtained by the fan pressurization method was distributed from 3.8 to 16 cm^2/m^2. The concentration measurements of CO_2 and NO_2 in the living rooms showed that the two houses with unvented oil space heaters were more polluted than the other houses. The total annual amount of energy consumption was distributed from 46 to 100 GJ.

INTRODUCTION

In Hokkaido, the northern-most island of the Japanese Archipelago, the newly constructed residential buildings are well insulated and well heated due to the severe climate in the winter and to the significant concern for improvement of the indoor thermal environment since the end of the World War II. The Hokkaido local government originally passed legislation concerning the insulation of houses. This law has been revised several times. Nowadays, newly constructed houses have heavy insulation in many cases, that is, the depth of fiberglass insulation in the ceiling, walls, and floor is 20 cm, 15 cm, and 10 cm, respectively.

On the other hand, the Japanese national government passed legislation concerning building insulation standards for the first time after the oil crisis in 1973. This law prescribed a recommendation for the insulation performance of a housing envelope in each region of Japan. As a result, the mean ratio of newly constructed houses with a partially or totally insulated envelope in 1985 was 88% in all of Japan

according to the survey of the Glass Wool (Fiberglass) Association of Japan. Also, in Sendai, a local city in the Tohoku region, newly constructed detached houses have become more and more airtight and highly insulated. In such houses, it is expected that the quality of the indoor thermal environment will be better than that of existing houses. But there is the possibility of indoor air pollution, because unvented oil or gas space heaters are still popular in many homes.

The authors have investigated indoor temperature, airtightness, indoor air quality, and energy consumption in 13 units of new, detached houses in Sendai. There are many existing reports which reveal indoor temperature or indoor air quality in Japan. For example, Hasegawa and Yoshino (1987) showed the results of indoor temperature measurements of 139 houses in the Tohoku region and compared them with other measurement studies. And Nakai et al. (1987) reported the results of NO_2 concentration measurements in all-electric houses and houses using gas to prepare meals. However, there are no reports which investigate many factors relating to indoor climate and energy consumption in houses.

Sendai is the main city of the Tohoku region, which is in the northern portion of Honshu Island, and is located near the coast of the Pacific Ocean. The latitude of Sendai is 38°16'. The mean outdoor temperature in January is 0.9°C.

DESCRIPTION OF HOUSES MEASURED AND MEASUREMENT PERIOD

Table 1 describes the houses measured. All houses were built by the wood-frame construction method. The floor area of the houses measures from 105 to 183 m^2, which was nearly equal to or larger than the average of detached wooden houses throughout Japan [105 m^2 in 1983, as given by the Bureau of Statistics, Office of the Prime Minister, (1984)]. The occupants are the middle classes. Figure 1 illustrates the floor plans of the first floors of the houses in this study. These houses were constructed between 1981 and 1984. All of the structures have thermally insulated walls, ceilings, and floors, except for house no. 6 which has a concrete floor without insulation under it. The insulation material used was fiberglass. The depth of insulation in house no. 7, for example, which is the most heavily insulated, is 15 cm for the walls and ceiling, and 5 cm for the floor. The windows of all houses had double glazing or double sashes.

The houses constructed by contractor "A" had oil or gas space heaters for heating at least the living room. The oil or gas space heaters were divided into two types; one was an unvented heater and the other was a vented heater. An unvented heater takes in room air for combustion and expels the exhaust into the room. A vented heater takes in outside air for combustion and expels the exhaust outdoors. House no. 2 had an unvented oil space heater, which supplied hot air by a fan, for the living/dining room. House no. 4 had a vented oil heater for the living room as well as an unvented portable oil heater for the dining room. The other houses had vented oil heaters for the living room or the living/dining room. The main bedrooms measured had no space heater. The houses constructed by contractors "B" and "C" had concrete floors, including hot water pipes for floor heating and thermal insulation between the floor and the ground. The exception was house no. 6, which had a concrete floor without floor heating, but had a vented oil heater for the living and dining rooms. The three houses out of seven with floor heating also had fan coil units in the bedrooms of the second floor. In six houses out of thirteen with a space heater or floor heating, an electric heater "Kotatsu" is also used in the living room. A "Kotatsu" is a Japanese style electric heater which is mounted under a low table covered with a quilt. People sitting on the floor heat their legs under the low table.

The investigated structures without floor heating were typical among the newly-built houses in Sendai, but the houses with floor heating are not so popular and are built by only two or three contractors. The measurements were made during January and February of 1985.

INDOOR THERMAL ENVIRONMENT

Method of measurement

Temperatures at six points in each house were measured continuously for seven to ten days by resistance thermometers. The number of days for measurement was different between the houses because of the need to accommodate the occupants. The points measured, which are shown in Fig. 1, were in the living room (5 cm and 1.1 m above the floor level), the main bedroom, the entrance hall, outside the house, etc. Radiant temperature was measured by using a globe thermometer in the living room at a point 1.1 m above the floor level.

Outdoor temperature during the measurement period

The average outdoor temperature was about -0.6°C for the first half of the measurement period (Jan. 25 to Feb. 3) and about 2.3°C for the latter half of that period (Feb. 5 to 12).

Table 1. Description of measured houses.

House number	Date of completion	Floor area (m^2)	Depth of insulation (cm)†			Window	Heating in living room Equipment	Hours* in a day	Months in a year
			Wall	Floor	Ceiling				
1	Jan.1983	109	5	5	7.5	D.S.	Vented oil heater	9.8	--
2	Jan.1983	105	5	5	7.5	D.S.	Unvented oil heater & "Kotatsu"	8.9	4.6
3	Jan.1983	109	5	5	7.5	D.S.	Vented gas heater	6.5	4.6
4	Mar.1983	110	5	5	7.5	D.S.	Unvented & vented oil heaters	8.9	4.3
5	Dec.1984	109F	10	2.5	10	D.S.	Floor heating & "Kotatsu"	2.0 morning 1.5 evening	--
6	Sept.1984	142F	10	-	10	D.S.	Vented oil heater & "Kotatsu"	9.9	4.3
7	Sept.1984	183F	15	5	15	D.S.	Floor heating	2.0 morning	2.0
8	Jan.1982	110	5	5	7.5	D.G.	Vented oil heater & "Kotatsu"	10.2	4.3
9	Oct.1984	152F	5	5	10	D.S.	Floor heating	2.0 morning 2.0 evening	--
10	Mar.1983	147F	5	5	10	D.G.	Floor heating & "Kotatsu"	1.0 morning 2.5 evening	6.6
11	Aug.1983	163F	5	5	10	D.S.	Floor heating	2.5 morning 3.0 evening	4.0
12	June1981	120F	5	5	10	D.G.	Floor heating	2.0 morning 2.0 evening	3.6
13	Aug.1981	109F	5	5	10	D.G.	Floor heating & "Kotatsu"	0.5 morning 1.0 evening	4.0

House number	Ventilation in living room	Heating equipment in bedroom	Family size	The age Max	Min	House builder
1	Natural	none	4	37	7	A
2	Natural	none	3	34	5	A
3	Natural	none	5	46	11	A
4	Natural	none	5	44	8	A
5	Mechanical‡	Electric heater	3	37	8	B
7	Mechanical	none	4	42	12	B
8	Natural	none	4	35	0	A
9	Mechanical	Fan coil unit & "Kotatsu"	6	72	3	C
10	Natural	"Kotatsu"	4	44	12	C
11	Natural	Fan coil unit	5	45	9	C
12	Mechanical	Fan coil unit	4	35	3	C
13	Mechanical	Floor heating	4	47	13	C

F=concrete floor is constructed. D.S.=double sashes, D.G.=double glazing. All houses have two stories except for house #13 with a flat. "Kotatsu" is a Japanese style electric heater which is mounted under the low table covered with a quilt.

*The average in winter for the floor heating and during the measuring period for the others

†Insulation materials are glass wools.

‡"Mechanical ventilation" means an exhaust fan unit, which is situated in outer wall, with air-to-air heat exchanger, except for house #13.

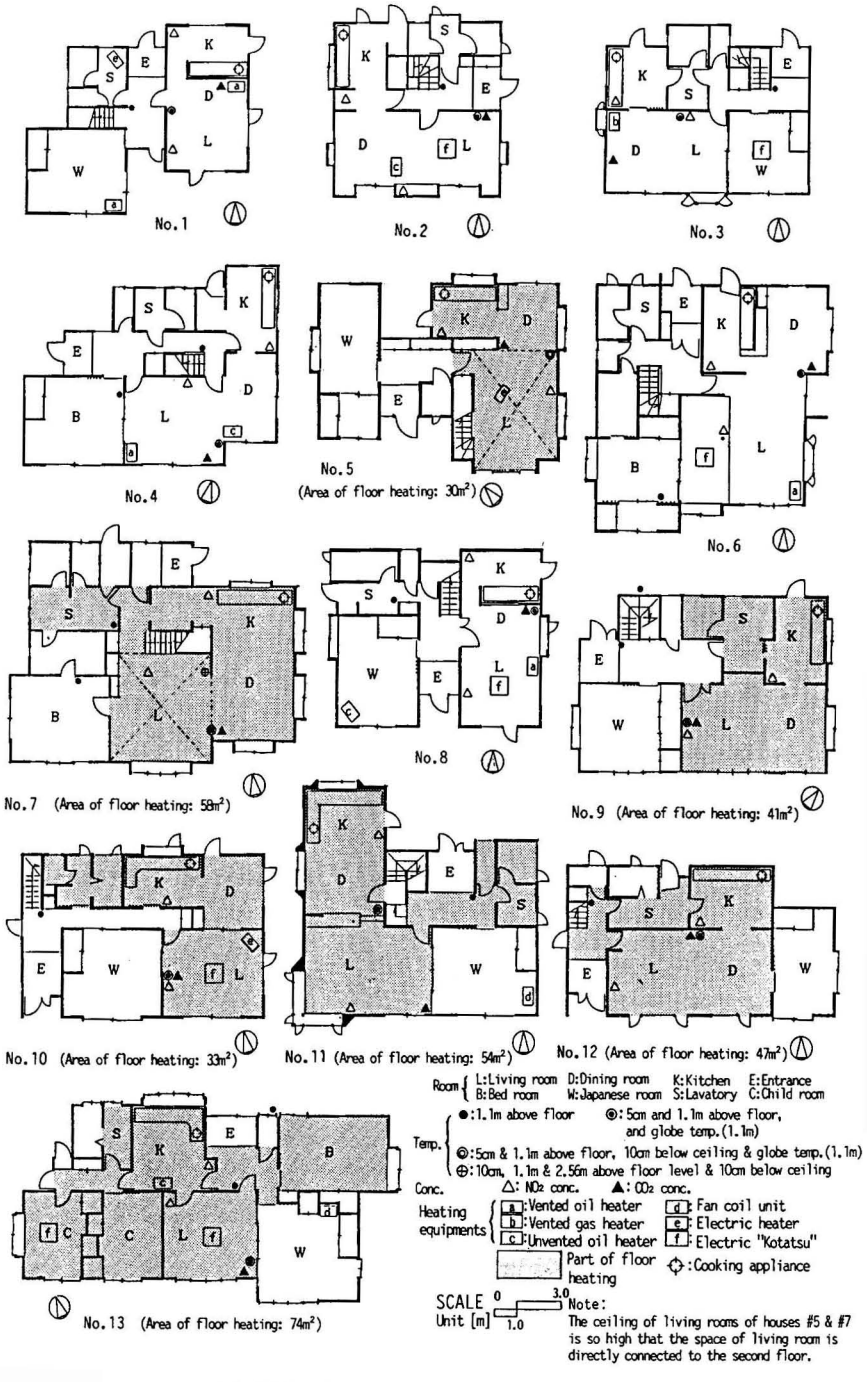

Fig. 1. Floor plans of the first floor of the houses measured.

Profiles of room temperatures

Figure 2 shows the average room temperature profiles of house no. 1 with a vented oil heater installed in the living room and of house no. 7 furnished with floor heating. The room temperatures, read every 30 minutes, were averaged for the measurement period. The living room temperature at a point 1.1 m above the floor level in house no. 1 was maintained around 20°C during the evening family time after supper. But after the heater was turned off, the room temperature fell rapidly and became 10°C by daybreak. The living room temperature at a point 5 cm above the floor level was 6°C lower than the temperature at 1.1 m. There was a high temperature stratification in the living room. Radiant temperature in the living room was 1°C lower at the maximum than the dry-bulb temperature during the heating time. The temperatures of the entrance hall and the main bedroom were lower and remained between 5 and 10°. The high temperature stratification in the living room seemed to be due to cold air infiltration from the unheated corridor or the entrance hall. On the other hand, the room temperatures of house no. 7 with floor heating remained high all day long. Although hot water was circulated through pipes in the concrete floor for only two hours from 7 to 9 AM, living room temperature at a point 1.1 m high was 17 - 22°C all day long due to the heat storage effect of the concrete floor. There was no temperature difference between the points 1.1 m and 5 cm above the floor level in the living room. Radiant temperature was nearly equal to or a little higher than the dry-bulb temperature. The temperature of the bedroom and that of the washroom was 15 - 20°C.

Figure 3 shows the temperature profiles of the living rooms of the other houses with space heaters or floor heating, respectively. Each group of living rooms had different temperature profiles from one another, as shown in Fig. 2. Although the operating hours of floor heating were short, for example only 5.5 hours at the maximum among the houses with floor heating, the temperature of each living room remained stable all day long. The outdoor temperatures were measured outside of several houses during two different periods. Therefore, three and five temperature profiles are shown in Fig. 3a and 3b.

Relationship between outdoor and room temperatures

Figure 4 shows the regression lines between the daily mean outdoor temperature and the indoor temperature in three different spaces; living room, main bedroom, and entrance hall. In the living room, two different regression lines are shown for each house. The broken line represents the temperature averaged during the evening family time. The other represents the temperature averaged during a whole day. It is generally expected that the slope of the regression line comes near to zero when a space is well heated. In almost all of the houses, the slope is up toward the right, that is, the indoor temperature increased during the day with higher outdoor mean temperature. But

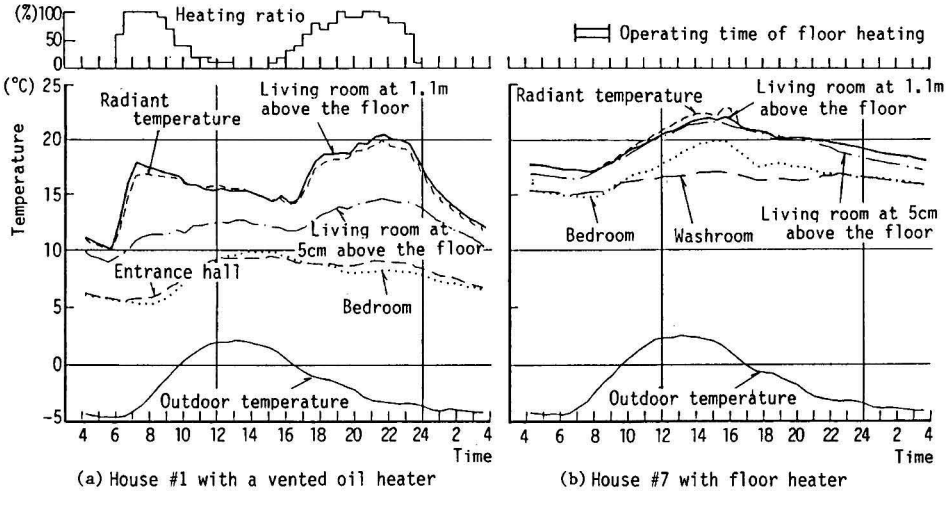

Fig. 2. Profiles of the mean room temperatures of two houses during a one-day period. House no. 1 has a vented oil space heater for the living room only. House no. 7 has hot-water pipes embedded in the concrete floor for floor heating of the first floor. There are different temperature profiles between the two houses. The room temperatures, read every 30 minutes, were averaged for 10 days and 7 days for house no. 1 and house no. 7, respectively.

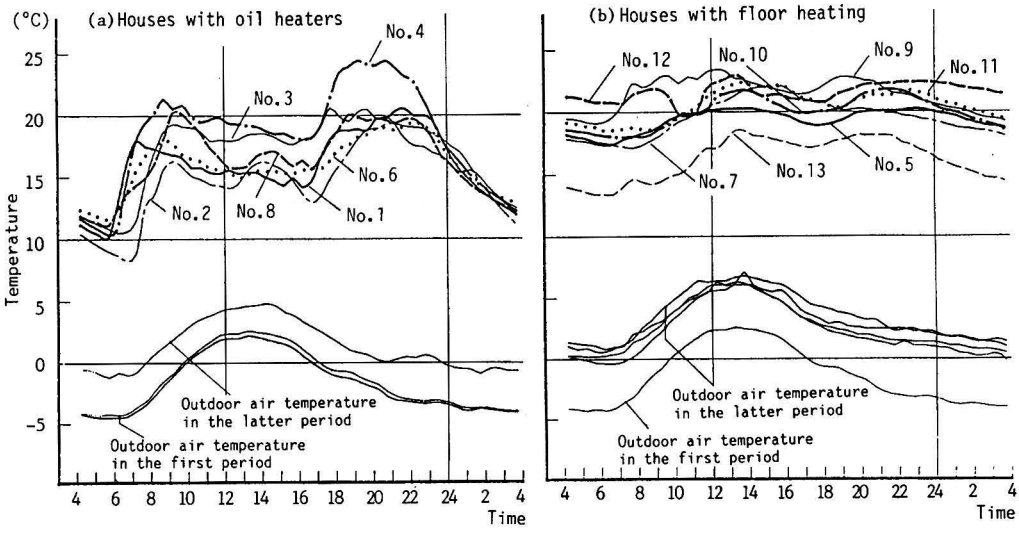

Fig. 3. Profiles of the mean living room temperatures at the point 1.1 m in height in the houses with a space heater or floor heating. Each group of living rooms has different temperature profiles from one another, as shown in Fig. 2. The outdoor temperatures were measured outside of several of the houses during two different periods. Therefore, 3 and 5 profiles were shown in Fig. 3a and 3b.

in the living rooms of three of the houses, the indoor temperature averaged during the evening family time decreased during the day with higher outdoor mean temperature. The slope of the regression line is relatively sharp in main bedrooms and entrance halls. The correlation coefficient of each space is greater in the order of the living room, bedroom, and entrance hall. Therefore, it can be said that the indoor temperature of the bedroom and the entrance hall greatly depends upon the outdoor temperature.

When the outdoor temperature was 0°C, the mean temperature of the houses with a space heater was 21.9°C during the evening family time in the living room, and 16.5°, 11.3°C, and 8.6°C (daily mean value) in the living room, main bedroom, and entrance hall, respectively. On the other hand, the mean temperature of the houses with floor heating for an outdoor temperature of 0°C was 21.9°C during the evening family time in the living room. That temperature is the same as the value of the living room with a space heater. The daily mean value in the living room, main bedroom, and entrance hall was 19.0°C, 14.2°C, and 12.6°C, respectively. These temperatures were higher than those of the houses with a space heater.

According to the measurement results by Hasegawa et al. (1980) in houses with a space heater, which were constructed by the local public housing corporation of Miyagi Prefecture, the mean temperature for an outdoor temperature of 0°C was 22.0°C in the evening family time in the living room, and 15.1°C, 8.0°C, and 6.2°C (daily mean value) in the living room, main bedroom, and corridor, respectively. The living room temperature during the evening family time measured in 1980 was nearly equal to the living room temperature with a space heater as measured during the present study. But the daily mean temperature of each room was 4°C to 6°C lower than that of the present study.

Vertical temperature difference in living room

Figure 5 shows the relationship between the vertical temperature difference and the indoor-outdoor temperature difference. The vertical temperature difference means the temperature difference between 5 cm and 1.1 m above the floor level. These temperatures were averaged during the evening family time or during the whole day for the measurement period. The points plotted were divided into two groups, space heaters and floor heating. The vertical temperature difference measured in houses with a space heater was lower. The ratio of the temperature difference between 5 cm and 1.1 m in height to the indoor-outdoor temperature difference (non-dimensional vertical temperature) is 0.2 to 0.3. According to the results of indoor temperature measurement of 139 houses in the Tohoku region by Hasegawa and Yoshino (1987), the non-dimensional vertical temperature of existing houses with space heaters was distributed from 0.2 to 0.6. That value of 0.2 to 0.3 in this measurement is comparatively low.

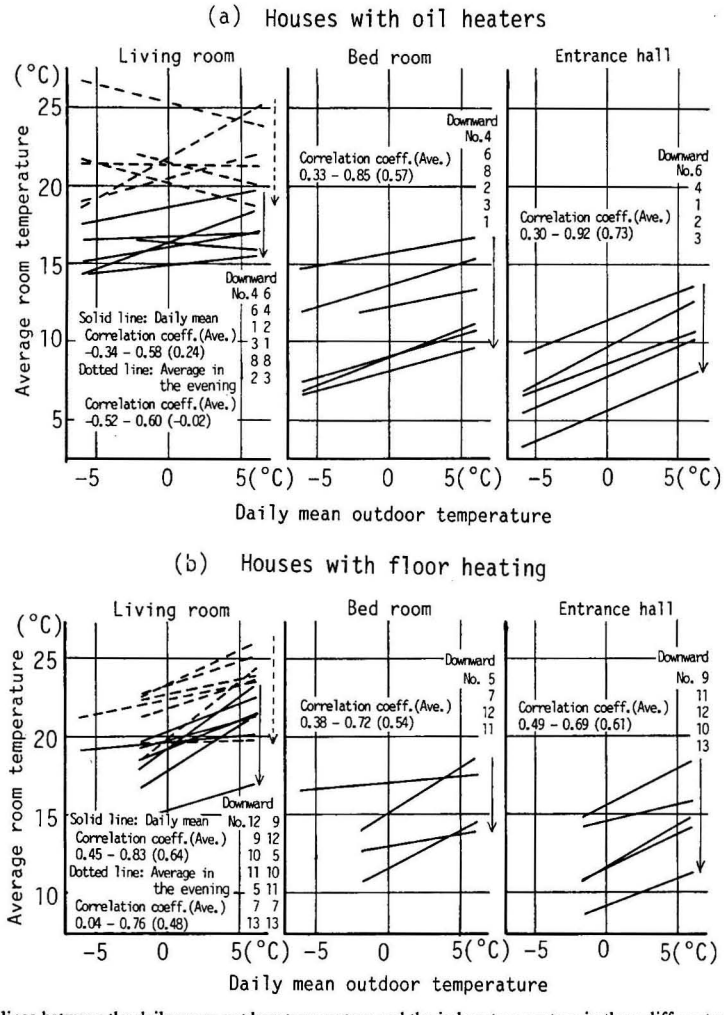

Fig. 4. Regression lines between the daily mean outdoor temperature and the indoor temperature in three different spaces; living room, main bedroom, and entrance hall. In the living room, two different regression lines are shown for each house. The broken line represents the temperature averaged during the evening family time. The solid line represents the temperature averaged during a whole day.

On the other hand, the vertical temperature difference of the houses with floor heating was very small. The nondimensional vertical temperature was less than 0.1. In some cases, however, the temperature at 5 cm above the floor level was higher than the temperature at 1.1 m. In houses no. 5 and no. 7, the temperature at 10 cm below the ceiling was measured in the living rooms which had a high ceiling just below the two-story roof. In house no. 5, the room temperatures during the evening at points 5 cm and 1.1 m above the floor and 10 cm below the ceiling were 21.2°C, 21.8°C, and 21.9°C, respectively. In house no. 7, the room temperatures at these same points were 22.1°C, 22.6°C, and 22.1°C, respectively. The vertical temperature difference was extremely small, due not only to the effect of floor heating but also to the high degree of thermal insulation and airtightness.

Radiant temperature

Figure 6 shows the relationships between the nondimensional vertical temperature and the radiant temperature difference, which is the difference between radiant temperature and dry-bulb temperature. These temperatures in the living rooms were averaged during the evening family time for about

tendays.Thepointsplottedarealsodividedintotwo groups, as shown in Fig. 5, and there is a minus correlation between the two factors. In the living rooms with floor heating, not only was the nondimensional vertical temperature small, but the radiant temperature was also 1°C higher at the maximum than the dry-bulb temperature due to the effect of radiation from the floor surface. That is, the living room with floor heating was thermally more comfortable than the rooms with a space heater.

Temperatures of other rooms

Figure 7 shows the temperature difference between the living room and the other rooms averaged during the evening family time for the measurement period. Each temperature is indicated as the difference from the outdoor temperature. The temperatures of the other rooms were lower than the living room temperature in all of the houses. The ratio of the temperature of the other rooms to the living room temperature was widely distributed from 0.3 to 0.9. According to the results of the questionnaire on thermal sensation, almost all occupants perceived the temperatures of the living room and the kitchen as being "neutral," but half of the occupants perceived the temperatures of the bedroom and the entrance hall to be "a little cold."

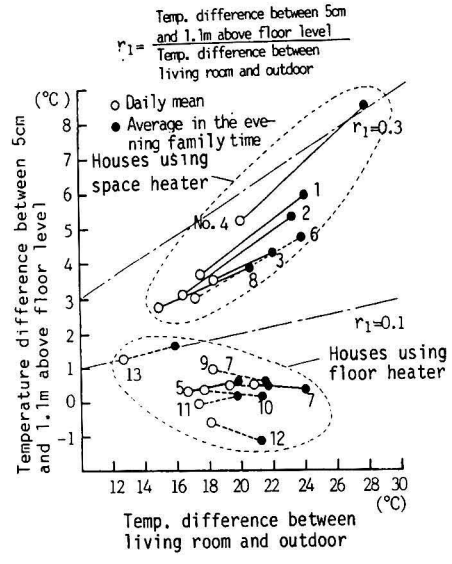

Fig. 5. Vertical temperature difference and indoor-outdoor temperature differences in the living room which were averaged during the evening family time or during a whole day for the measurement period. The points plotted are divided into two groups: space heaters and floor heating. The indoor temperature of house no. 7 was measured for two different periods.

List of symbols

- Q air flow through the building envelope (m^3/h)
- Qr air flow at reference conditions (m^3/h)
- Δp pressure difference across the building envelope (Pa)
- Δp_r pressure difference at a reference condition (Pa)
- n exponent of the pressure difference
- Ar effective leakage area at a reference condition (m^2)
- Ar* Ar per floor area; specific leakage area (cm^2/m^2)
- ρ density of air (kg/m^3)
- r_1 non-dimensional vertical temperature, which means the ratio of temperature difference between 5 cm and 1.1 m above a floor level to temperature difference between living room and outdoors
- r_2 room temperature decreasing rate, which means the ratio of various room temperatures to living room temperature. Each temperature is indicated as the difference from outdoor temperature

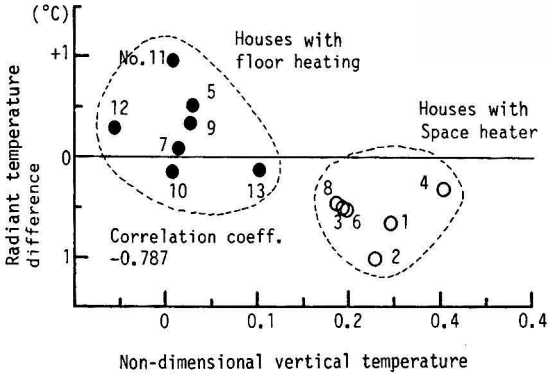

Fig. 6. The non-dimensional vertical temperature and the radiant temperature difference. The radiant temperature difference represents the difference between radiant temperature and dry-bulb temperature. These temperatures in the living rooms were averaged during the evening family time for the measurement period. The points plotted are divided into two groups as shown in Fig. 5. There is a minus correlation between the two factors.

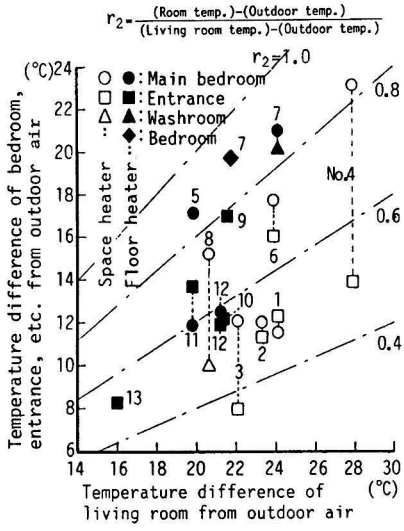

Fig. 7. Averaged temperature differences between the living room and the other rooms averaged during the evening family time for the measurement period. Each temperature is indicated as the difference from the outdoor temperature.

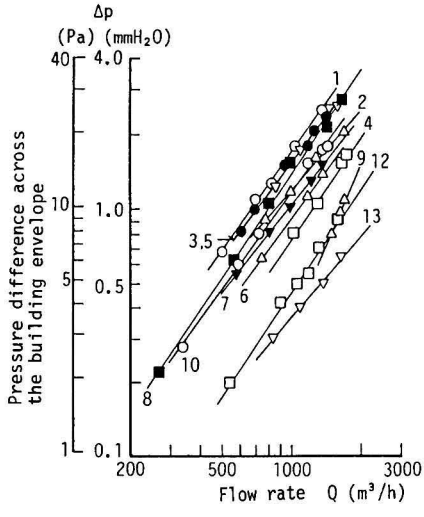

Fig. 8. Pressure difference across the building envelope and the volumetric flow rate of 12 houses, without house no. 11. The airtightness of house no. 11 could not be measured due to high wind speed despite three attempts on different days.

Table 2. Airtightness of measured houses.

House No.	Air flow Q_r(m³/hr)	n	ELA[a] A_r(cm²)	SLA[b] A_r^*(cm²/m²)
1	672	1.29	463	4.24
2	845	1.07	598	5.70
3	706	1.24	500	4.61
4	1200	1.37	851	7.73
5	706	1.22	500	4.61
6	1060	1.28	748	5.27
7	973	1.18	688	3.77
8	792	1.39	560	5.10
9	1630	2.19	1150	7.56
10	882	1.30	624	4.23
11	--	--	--	--
12	1720	1.40	1210	10.17
13	2470	1.11	1750	16.08

[a] Effective Leakage Area at 9.8 [Pa]
[b] Specific Leakage Area = ELA/floor area

AIRTIGHTNESS OF INVESTIGATED HOUSES

Method of measurement

Airtightness measurements were made by the fan pressurization method (Narasaki and Kusumi 1974; Stricker 1975). Internal pressure was increased by a fan attached to a duct penetrating a thin board set in a window. The pressure differences were measured by a capacitance manometer. Flow rate in the duct was measured by a thermistor anemometer. Measurements were carried out at the indoor-outdoor pressure difference from 2 to 30 Pa in almost all of the houses. But in leaky houses, it was impossible to increase the pressure difference more than 10 Pa.

Measured results

Figure 8 shows the relationship between the pressure difference across the building envelope and the volumetric flow rate of 12 houses, excluding house no. 11. This relationship is expressed by

$$Q = Qr\left(\frac{\Delta p}{\Delta p_r}\right)^{\frac{1}{n}} \quad (1)$$

Table 2 shows the volumetric air flow through the building envelope, Qr, for the pressure difference between the building envelope, Δp_r, of 9.8 Pa. Also shown is the exponent of the pressure difference, n of Eq. 1 estimated by regression lines. The value of exponent n for house no. 9 was unreasonably high, more than 2.0. One of the reasons may be that more than three times measurements could not be made and data obtained were unstable due to high wind speed. Except for house no. 9, the value of n ranged from 1.07 to 1.40. Table 2 also shows the effective leakage area, Ar, for each house, which can be calculated by the following equation.

$$Ar = 2.78\,Qr\,(2\Delta P_r/\rho)^{-0.5} \quad (2)$$

In Eq. 2, Δp_r is given as 9.8 Pa. The effective leakage area per floor area (specific leakage are), Ar*, is also included in Table 2. The value of Ar* was widely distributed from 3.77 to 16.1 cm^2/m^2. The airtightness of house no. 11 could not be measured due to high wind speed despite three attempts on different days.

Comparison of airtightness using effective leakage area per floor area

Figure 9 shows the effective leakage area per floor area for various houses in different countries. Where the original airtightness data were not shown as Ar for Δp_r=9.8 Pa, these data were converted, assuming 1/n=0.6. The original figure is presented in the paper by Murakami and Yoshino (1983).

The houses measured in this test were ranked 3 through 5 in airtightness. Except for houses no. 12 and no. 13, airtightness of the houses was higher than that of the houses measured in the past by Yoshino et al. (1981) in Sendai. Although there is no standard or recommendation of airtightness for a building envelope in Japan, this figure shows that the houses with rank of 3 were comparatively airtight for detached Japanese houses.

Among the houses constructed by contractor A, house no. 1, which has hinged windows with double panes, is the most airtight. Houses no. 2, no. 3, and no. 4 have sliding double sashes. House no. 8 has hinged windows with double panes, except for the traditional Japanese room with the sliding sashes with double panes. Among the houses constructed by contractor B, house no. 7, which was constructed with airtightness in mind, is the most airtight. Houses no. 5, no. 6, and no. 7 have the ventilation fan unit

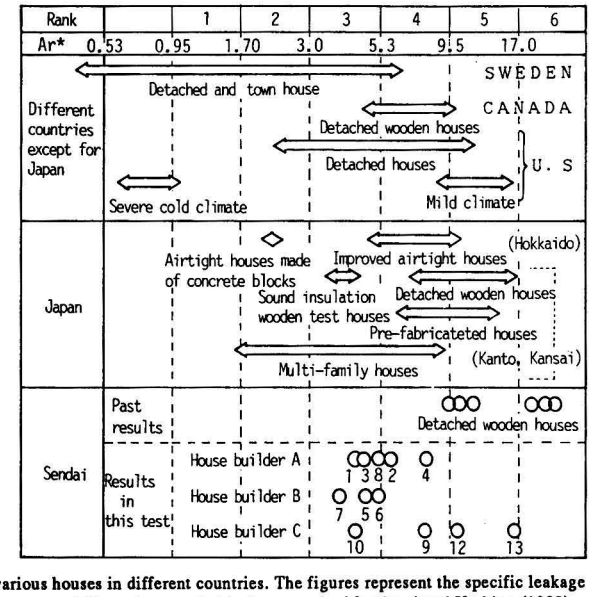

Fig. 9. Airtightness for various houses in different countries. The figures represent the specific leakage area for Δp=9.8 Pa. The original figure is presented in the paper by Murakami and Yoshino (1983).

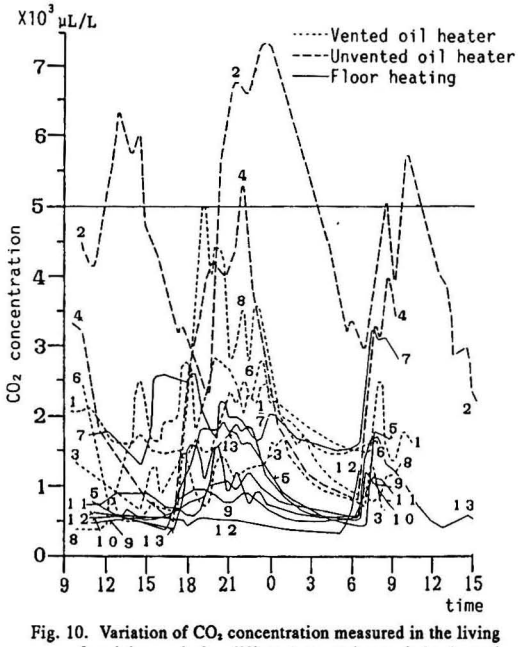

Fig. 10. Variation of CO_2 concentration measured in the living room of each house during different measuring periods. According to ASHRAE Standard 62-1981 and the other literature, it is generally felt that 5000 μL/L is an upper limit of CO_2.

with an air-to-air heat exchanger mounted in the outer wall. But the occupants in these houses stated that they felt air infiltration, even though the unit was not operating, when the outdoor wind speed was high. The airtightness of the houses constructed by contractor C varied greatly. House no. 13, which is plotted at the extreme right side, has sliding sashes and leaky sliding entrance doors. House no. 11, for which airtightness was not tested, is expected to be plotted between house no. 10 and house no. 9, considering the construction method and the type of windows and doors.

INDOOR AIR QUALITY

Method of measurement

The concentration of CO_2 was measured continuously for one or two days in the living room of each house by an infrared analyzer. The concentration of NO_2 was measured by bare detector badges exposed for three days in the living room and the kitchen. This measurement follows the method utilized by Yanagisawa and Nishimura (1980). The locations of the measurement points are shown in Fig. 1.

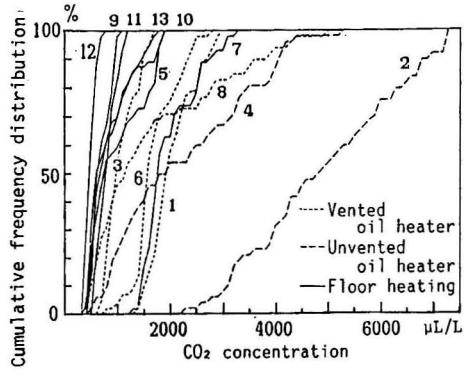

Fig. 11. Cumulative frequency distribution of CO_2 concentration.

Measured results of CO_2 concentration

Figure 10 shows the variation of CO_2 concentration measured in the living room of each house during different measuring periods. The concentration of CO_2 rose in the morning and in the evening due to CO_2 generation from occupants and cooking apparatus as well as, in some houses, from unvented oil heaters. At 9:00 PM, the concentration was distributed from 500 to 7000 μL/L. The concentration in

Table 3. Mean concentration of CO_2 and NO_2. CO_2 concentration was averaged for a day. NO_2 concentration was averaged for 2 to 3 days.

House No.	CO_2 concentration (μL/L)	NO_2 concentration (μL/L)	
		Living room	Kitchen
1	1980	22	29
2	4990	470	420
3	1230	10	18
4	2240	63	49
5	980	7	12
6	1720	13	21
7	1990	11	11
8	1660	31	60
9	690	10	11
10	870	20	29
11	800	11	9
12	500	9	11
13	810	4	25

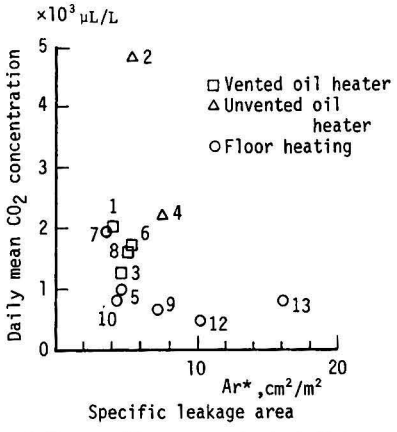

Fig. 12. Daily mean CO_2 concentration in the living room and the effective leakage area per floor area. The concentration of CO_2 is very high for the two houses with unvented portable oil heaters. With the exception of these two houses, the CO_2 concentration in five out of the seven houses with an Ar* value smaller than 6 cm^2/m^2 is more than 1000 μL/L.

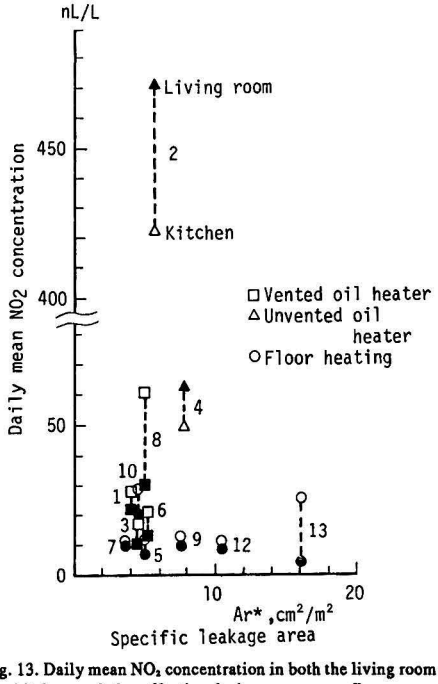

Fig. 13. Daily mean NO_2 concentration in both the living room and the kitchen and the effective leakage area per floor area. The concentration of NO_2 is extremely high in one house with an unvented portable oil heater which supplies hot air. In the houses with unvented heaters, the NO_2 concentration of the living room is higher than that of the kitchen. On the other hand, in the houses without unvented heaters, the NO_2 concentration of the kitchen was higher than that of the living room due to NO_2 generation from the gas cooking stove in the kitchen.

house no. 2 with an unvented oil heater was especially high. According to ASHRAE Standard 62-1981 and Sato (1965), it is generally felt that 5000 μL/L is an upper limit of CO_2. The Building Standards Code of Japan prescribes that the limit of CO_2 for indoor air in air-conditioned spaces of office buildings be less than 1000 μL/L.

Figure 11 shows the cumulative frequency distribution of CO_2 concentration during a day. In houses no. 1, no. 2, no. 4, no. 6, and no. 7, the CO_2 concentration was more than 1000 μL/L for more than 70% of the time. In houses no. 1, no. 2, and no. 7, the concentration was more than 1000 μL/L all day long. Unexpectedly, the concentration in house no. 2 was more than 2000 μL/L all day long. Houses no. 2 and no. 4 have unvented oil heaters. Houses no. 1 and no. 7 were the most airtight among the 13 houses measured for this test. The houses with floor heating systems, except for house no. 7, show a rather low CO_2 concentration. Table 3 shows the mean concentration of CO_2 for a one-day period.

Measured results of NO_2 concentration

Table 3 also shows the mean NO_2 concentration for two to three days in the living rooms and kitchens. The concentration in house no. 2 was extremely high. The second highest concentration was in house no. 4. In all of the houses, except for the two houses with unvented oil heaters and house no. 11, the concentration in the kitchen was higher than that of the living room due to NO_2 generation from gas cooking stoves in the kitchen.

The relationship between airtightness and indoor air quality

Fig. 12 shows the relationship between the effective leakage area per floor area, Ar*, and the daily mean concentration of CO_2. The CO_2 concentration was very high for houses no. 2 and no. 4 due to the usage of unvented portable oil heaters. With the exception of these two houses, the concentration in five out of the seven houses with an Ar* value smaller than 6 cm^2/m^2 was more than 1000 μL/L. As this sample was too small, it is difficult to say that there was a correlation between the leakage area and the CO_2 concentration. However, the figure suggests that the indoor air of the houses with an airtightness rank of less than 3 were easily polluted. Figure 13 shows the relationship between Ar* and the daily mean concentration of NO_2, which is similar to that shown in Fig. 12.

The saturation level of unvented heaters in Japan was 80% in 1986, as reported by the Research Bureau

Table 4. Measurement period of energy consumption and main energy uses.

House number	Measurement period	Main energy uses			Conversion value
		Electricity	Gas	Oil	
1	Oct.1984-Sep.1985		Cooking, hot water	Heating	Electlicity
2	Nov.1984-Oct.1985		Cooking, hot water	Heating	1kwh=3.6MJ
3	Oct.1984-Sep.1985	*	Heating, cooking and hot water	Nothing	
4	Dec.1984-Nov.1985		Cooking, hot water	Heating	City gas:
5	Mar.1985-Feb.1986		Cooking, hot water	Heating	$1m^3$=21.0MJ
6	Nov.1984-Oct.1986		Cooking, hot water	Heating	
7	Feb.1985-Jan.1986		Cooking	Heating, hot water	Propan gas:
8	Dec.1984-Nov.1985		Cooking, hot water	Heating	$1m^3$=101MJ
9	Nov.1984-Dec.1985		Cooking	Heating, hot water	
10	Oct.1984-Sep.1985		Cooking	Heating, hot water	Oil:
11	Dec.1984-Nov.1985	*	Cooking, hot water	Heating	1L=36.9MJ
12	Aug.1984-Jul.1985	*	@Cooking	Heating, hot water	
13	Oct.1984-Sep.1985		@Cooking	Heating, hot water	

All houses are using electricity for lighting, etc.
* the house with air conditioner
@ the house using propane gas, other houses using city gas

of Economic Planning Agency (1987). In traditional leaky houses with unvented heaters, it was expected that much air infiltration prevented indoor air from being polluted. But in the recently constructed houses with low infiltration and unvented heaters, there was a strong possibility of indoor air pollution.

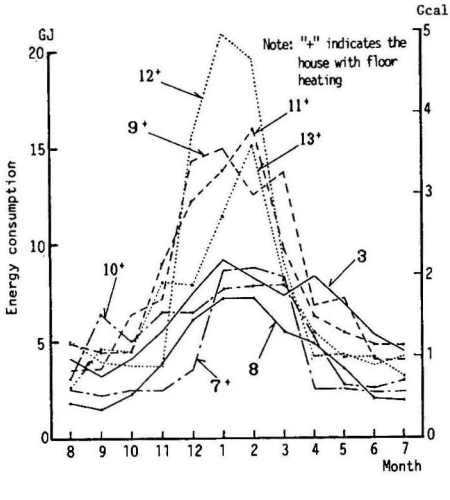

Fig. 14. Annual profiles of monthly energy consumption in 8 houses for which the energy data for 12 months was obtained. The increase in monthly energy consumption from November to March was due to space heating.

Even if an unvented heater was not used, indoor air in the many houses with an airtightness rank of less than 3 was expected to become polluted. Therefore, it is necessary to forcibly ventilate indoor air in such houses.

ENERGY CONSUMPTION

Method of measurement

Monthly consumptions of electricity, gas, and oil for each house were calculated on the basis of the utility bills of occupants. Table 4 shows the main energy uses in each house and the conversion value of electricity, gas, and oil into joule units. Data for a one-year period, which was slightly different from house to house, was obtained for the period between August 1984 and February 1986.

Annual profiles of energy consumption

Figure 14 shows the annual profiles of monthly energy consumption in eight houses for which the energy data for 12 months was obtained. The increase of monthly energy consumption from November to March was probably due to space heating. The degree of increase was high in the four houses with floor heating. The maximum value of monthly energy consumed in these four houses was more than 12.6 GJ. Three houses out of four had fan coil units on the second floor in addition to the floor heating on the first floor. The other structure, house no. 13, which

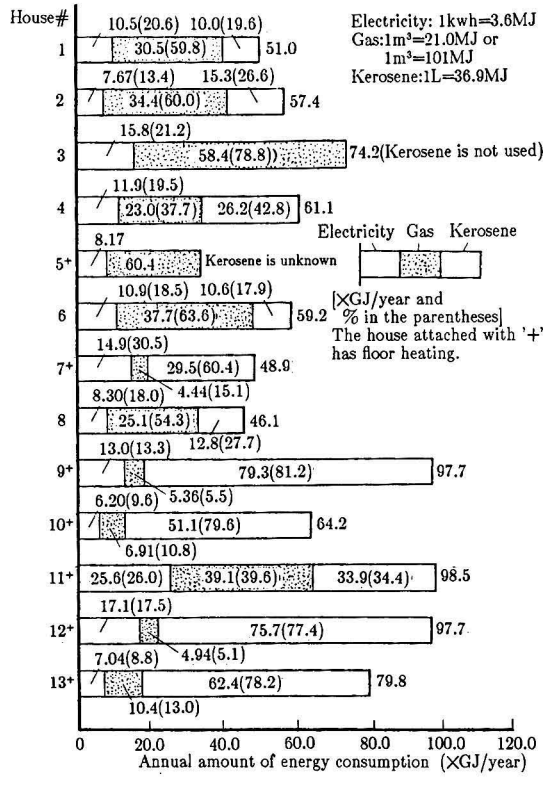

Fig. 15. Annual amount of energy consumption and its source. The amount of houses no. 9, no. 11, no. 12, and no. 13 was greater than the other houses due to a greater amount of energy consumed for space heating. But, the amount of energy consumed in well-heated house no. 7, which was the best insulated and most airtight among the investigated houses, was half that of houses no. 9, no. 11, and no. 12 and nearly equal to that of houses with a space heater installed in just the living room. These facts show that it is possible to improve indoor climate by constructing houses with good insulation and airtightness qualities, without increase of energy consumption for heating.

was a flat, had a fan coil unit in a traditional Japanese room with Tatami (woven straw) mat.

Annual amount of energy consumption

Figure 15 shows the annual amount of energy consumption and its source in each house. The amount of annual energy consumption was distributed from 46 to 100 GJ, except for house no. 5, with no data of oil consumption. The mean value was 70 GJ. The amount of energy consumed in houses no. 1, no. 2, no. 4, no. 6, and no. 8, in which the living room was only heated by an oil space heater, was rather small and distributed from 46 to 60 GJ. In house no. 4, the amount of oil consumption was greater because of usage of two oil heaters in the living room.

On the other hand, the amount of energy consumed in houses no. 7, no. 9, no. 10, no. 11, no. 12, and no. 13, all with floor heating, was distributed from 46 to 99 GJ. The amount of energy used in houses no. 9, no. 11, no. 12, and no. 13 was greater than the other houses due to the greater amount of energy consumed for space heating. That was to be expected because Fig. 14 shows the high increase during the winter due to space heating. In houses no. 9, no. 12, and no. 13, oil was used for both space heating and hot water heating. Considering the share of each kind of energy source and its end use, as shown in Table 4 in the other houses, it is estimated that more than half of the oil consumption was used for space heating.

As shown in Figs. 3, 4, and 7, of all the houses with floor heating, the living rooms were, along with the

other rooms, well-heated all day long. However, the other rooms of houses with floor heating had room temperatures higher than that of the houses with space heaters. And the amount of energy consumed for heating in four houses out of seven with floor heating was greater than the other houses. But, the amount of energy consumed in well-heated house no. 7, which was the best insulated and most airtight among the investigated houses, was half that of houses no. 9, no. 11, and no. 12 and nearly equal to that of the houses with a space heater installed in just the living room. These facts show that it is possible to improve indoor climate by constructing houses with good insulation and airtightness qualities, without the increase of energy consumption for heating.

CONCLUSIONS

The authors investigated the indoor thermal environment, airtightness, indoor air quality, and energy consumption in 13 new houses of wood-frame construction in a local city of Japan in the winter of 1985. All houses had thermally-insulated walls, ceilings and floors, except for one house which had a concrete floor without insulation underneath. Eight houses had concrete floors for the first floor. The seven houses out of eight with concrete floors had hot-water pipes embedded in the concrete floors for floor heating, and had insulation under the floor on the grade. The three houses out of seven with insulation under the concrete floor also had fan coil units in the bedrooms on the second floor. The six other houses without floor heating had oil or gas local space heaters. The results measured are given as follows.

In the houses with space heaters, the living room temperature at 1.1 m above the floor was maintained around 20°C during the evening family time after supper. But after the heater was turned off, the room temperature fell rapidly and became 10°C by daybreak. In the evening family time after supper, the living room temperature at 5 cm above the floor was 4 - 8°C lower than the temperature at 1.1 m. The temperatures of the main bedroom and the entrance hall were lower than the temperature of the living room. The ratio of the temperature of the other rooms to the living room temperature was from 0.3 to 0.8. The temperature profiles of the houses were similar to those of the houses measured in 1980, which were constructed by the local public housing corporation. However, it can be said that the quality of the thermal environment of the houses recently built was better from the viewpoint of the vertical temperature difference in the living room as well as from the temperature difference between the heated living room and the other unheated rooms.

Indoor temperature in the houses with floor heating was stable during the period of one day due to the heat storage effect of concrete floors. The vertical temperature difference in the living rooms was extremely small. Radiant temperature in the living room was 1°C higher at the maximum than the dry-bulb temperature during the evening in the living room. That is, the living room with floor heating was thermally more comfortable than the rooms with a space heater.

Houses measured in this test had an effective leakage area per floor area, Ar*, of 3.77 to 16.1 cm^2/m^2. Compared with the airtightness of the other various houses, the houses which ranked 3 in airtightness with Ar* from 3.0 to 5.3 cm^2/m^2 were comparatively airtight for Japanese detached houses.

The concentrations of CO_2 and NO_2 in the living rooms of the two houses with unvented portable oil heaters was very high. A daily mean value of CO_2 concentration was 4.99 mL/L for one house and 2.24 mL/L for the other house. The values of NO_2 were 470 nL/L and 63 nL/L, respectively. Aside from these two houses, the daily mean concentration of CO_2 in five out of the seven houses with an Ar* ranking of 3 was 1.2 to 2 mL/L.

The amount of annual energy consumption was distributed from 46 to 100 GJ, except for house no. 5 with no data of oil consumption. The mean value was 70 GJ. The amount of energy consumed in houses no. 7, no. 9, no. 10, no. 11, no. 12, and no. 13, all using floor heating, was distributed from 46 to 99 GJ. The amount of energy consumed in houses no. 9, no. 11, no. 12, and no. 13 was greater than the other houses due to a greater amount of energy consumed for space heating. But, the amount of energy consumed in well-heated house no. 7, which was the most heavily insulated and airtight among the investigated houses, was half that of houses no. 9, no. 11, and no. 12 and nearly equal to that of houses with a space heater installed in just the living room. These facts show that it is possible to improve indoor climate by constructing houses with good insulation and airtightness qualities, without an increase in energy consumption for heating.

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INDOOR DUST FALL AND ITS COMPOSITION IN TWO PUBLIC AREAS OF A CITY IN INDIA

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The paper reports the estimates of dust fall and its chemical composition in certain indoor areas of Hyderabad - Secunderabad Railway Station and a big domestic mess. The quantity of dust fall; percentage of living matter in aerosols; and the pH, SO_4, Cl, Fe, Co, Zn, Mn, and Cu contents of dust were analyzed. The deposition of airborne dust particles was 102 to 180 mg/m² · d in the railway station, while in the mess it was 52 to 97 mg/m² · d.

INTRODUCTION

Air pollution, with special refrence to particulate matter, has been identified as a growing problem in several urban cities in India. This is due to steep increases in the use of coal and wood as fuel for domestic and industrial purposes. Public areas, like railway stations and hotels, are the major sites of indoor pollution because of the large-scale burning of coal and wood, the continuous flow of passengers, the generation of organic waste, and outdoor air pollution. The dust carries specific chemical and biological characters, since the proportion of metals arising from the above-mentioned contributing sources and the spectrum of microflora may vary considerably from site to site (Quraishi 1985; Van Bronswijk 1981). Indoor air pollution monitoring and its health effects are much needed because people spend most of their time indoors and are thus exposed to much indoor pollution (NRC 1981; Benson et al. 1972; Jalees end Dave 1979). Different studies have been carried out on indoor air pollution and its effects (Smith et al. 1983; Cooper 1980; Langmuir 1980). Very little data exist on the levels of particulate matter in the indoor environments of Hyderabad with specific reference to an Indian context. The present investigation evaluates the quantity and physico-chemical characteristics of dust on the railway platform and in a large domestic mess in Secunderabad.

MATERIALS AND METHODS

Two different types of indoor environments - railway station platform and a domestic mess - in Hyderabad were selected for study. The two sampling stations were chosen because they are large public places comprising various sources of indoor pollution, e.g., coal and wood used as a smoke-emitting fuel, a large flow of people, tobacco smoke, structural materials of platforms and walls, outdoor air pollution and other macroscopically seen particles like hairs, skin, fibers, waste food, etc.

The railway station platform is 300 m in length, with a flow of passengers amounting to 500 per hour. In total, 100 trains run on average per day, and they are powered by diesel and steam engines using lignite coal. In the domestic mess, food is prepared for 600 people daily. Coal and wood are used as fuel randomly at rates of 20 kg/d and 18 to 24 kg/d, respectively.

Glass plates (10 cm^2 coated with a thin layer of grease ware kept at six points in each location, 5 m above the ground (Chaphekar et al. 1980). Sampling was done at six points in order to derive a mean value of the entire area; sampling points were distanced at 50 m and 40 m from each other in the railway station and the mess, respectively. Three sets of glass plates were placed simultaneously at all the points for collection at intervals of 1, 15, and 30 days. The mass of dust deposition was calculated in terms of the difference between post and pre-exposure mass of the glass plates at every interval and is expressed as g/m^2. The particle size in μm and quantitiy were determined through the use of a microscope by using an ocular and stage micrometer. The settleable dust components have been divided into two categories - nonliving (inorganic matter) and living (organic-dead or alive). Living matter has been calculated in terms of percentage of the total dust components settled.

The chemical composition of particles was determined using the deposits collected during sweeps 30 times per day ($dust/m^2$). The pH of 1:10 dust solution was measured (Digisun, 700). Sulfates and chlorides were determined using the standard method (AOAC 1945, 1984). Heavy metals (Fe, Co, Zn, and Mn) were analyzed by an atomic absorption spectrophotometer (Parkin Elmer, 5000) after digesting one gram of dust (Jackson 1967). The mean value of six points from each location was presented for all parameters. The study was carried out over three different seasons - winter (W), summer (S), and rainy (R).

RESULTS AND DISCUSSION

It is evident from Table 1 that there was a greater amount of dust accumulation in the railway station than in the mess. It could be that there was more smoke at the railway station, thus resulting in greater emissions and accumulation of dust over a given period of time per unit area. The quantity of the accumulation was found to be less in the rainy season. There was an increase of approximately 20 times in the dust accumulation, from 1-day to 30-day interval exposures at both sites. However, the size of the particles increased in the 15-day and 30-day exposures due to the aggregation of the dust particles.

This process of the aggregation of dust particles was found to be more prominent during the rainy season. This may be due to changes in moisture levels that brought more agglomeration of particles, which resulted in the increased size during the rainy season. This would facilitate a decrease of suspended particulate matter in the air. Increase in the size of the aggregated particles made the overall number less. These are thus factors that can be attributed to a weak cleansing capacity. The size of the particles was found to be in the ranges of 7.5 to 10.7 μm and thus not of respirable size.

The findings show how the increase in the size of particulates brings in settleable dust via the force of gravity (Hooper & Hooper 1986). The low values in dust accumulation in the rainy season suggest that indoor levels respond very rapidly to changes in the ambient levels. This is to be expected since indoor-outdoor air exchange rates are normally kept very high during hotter periods of the year. Indoor deposition rates of 8.3 to 50 mg/m^2 are reported by Funso Akeredolu in the domestic houses of Nigeria (Akeredolu 1986). The studies conducted by Michael et al. (1984) in Arizona reported mostly suspended particulate matter in the range of 25.5 to 28 mg/m^3. Moschandreas et al. (1981) studied the effect of wood burning on indoor air quality in three residences in Boston, MA. Sexton et al. (1984) con-

Table 1. Size (microns) and weight (g) of settleable $dust/m^2$ collected in two different indoor environments.

		1 day		15 days		30 days	
		Size	Weight	Size	Weight	Size	Weight
Railway Station	W	9.7	0.23	21.3	3.10	48.2	5.10
	S	10.7	0.27	13.2	3.40	49.4	5.4
	R	9.1	0.25	9.4	0.50	80.6	3.06
Domestic Mess	W	7.7	0.13	17.3	1.83	23.3	2.59
	S	8.7	0.15	9.1	2.00	9.8	2.90
	R	7.5	0.21	25.1	0.30	90.6	1.56

Note: W = Winter; S = Summer; R = Rainy.

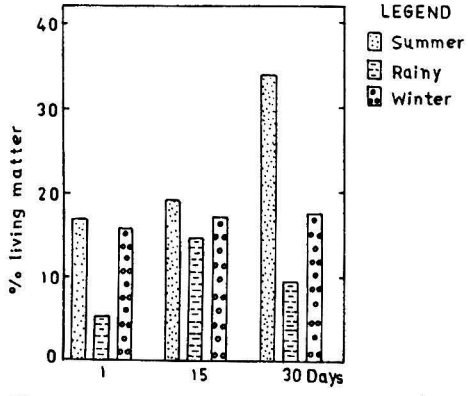

Fig. 1. Percentage of living matter in settleable dust/m² collected from the railway station in different seasons.

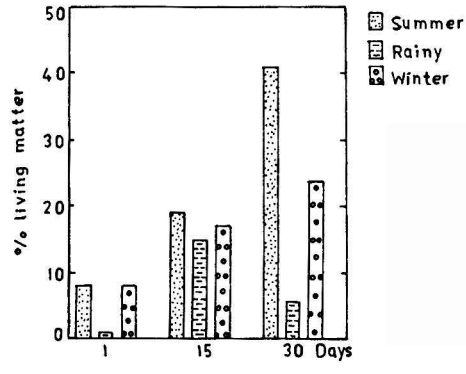

Fig. 2. Percentage of living matter in settleable dust/m² collected from the domestic mess in different seasons.

ducted an extensive study on indoor air quality in Waterbury, VT, involving 24 residences. Air pollution studies in subways were also carried out. In the present investigation, it was found that particulate matter pertaining to the concentration of dust was considerably high, perhaps due to emissions from wood and coal combustion.

The percentage composition of living and nonliving matter is given in Figs. 1 and 2. There is an increase in the percentage of the composition of living matter over a period of time from 1 to 30 days. A presence of living matter of less than 25% in most cases shows how the environment becomes undesirable. The microscopic examination of living matter has shown mostly pollens, insect larva, and certain fungal spores.

Sulfates, chlorides, and pH of the dust sweeps are given in Table 2. The concentration of sulfates and chlorides was more or less the same in both sites. The presence of sulfur and chloride concentrations in considerable amounts shows the higher amount of emissions from locomotives, the burning of wood in the mess, as well as the dust brought in by the large number of incoming passengers. It has already been established that the burning of coal and wood results in the production of sulfur and chlorides (Zeedijk 1986).

The analysis of heavy metal (see Table 3) has also revealed that the pollutant concentration was comparatively greater in indoor environments of the railway station. For the most part, the heavy metals could have been emitted from the combustion of coal (Quaraishi 1985; Zeedijk 1986). There was also a downward trend in the concentration of heavy metals during the rainy season. The sequence of the concentration of heavy metals in the dust was: Fe, Mn, Zn, Cu,and Co. Similarly, trace metals from indoor dust have been reported by different researchers (Davidson et al. 1986; Sexton et al. 1984).

Table 2. Concentration of sulfates, chlorides, and pH of 30-day dust sweeps.

Localities	SO_2^{2-} (mg/L)			Cl (mg/kg)			pH		
	W	S	R	W	S	R	W	S	R
Railway Station	6.0	6.8	4.3	14.1	24.8	10.6	8.0	8.5	6.5
Domestic Mess	4.3	5.1	3.4	2.0	3.2	2.1	6.5	6.0	6.0

Note: W = Winter; S = Summer; R = Rainy.

Table 3. Composition of certain heavy metals of 30-day dust sweeps (mg/kg).

		Fe	Co	Zn	Cu	Mn
Railway Station	W	25.9	0.27	1.17	1.14	13.33
	S	66.0	0.50	1.23	2.11	14.66
	R	18.0	0.20	0.95	0.76	10.33
Domestic Mess	W	15.9	0.05	0.95	0.55	6.66
	S	13.9	0.21	2.04	0.84	15.99
	R	9.9	0.33	0.95	1.29	6.65

Note: W = Winter; S = Summer; R = Rainy.

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EFFECT OF INDOOR AIR POLLUTION CAUSED BY DOMESTIC COOKING ON RESPIRATORY PROBLEMS OF ELDERLY WOMEN

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The purpose of the study was to assess the effect of indoor air pollution resulting from the use of gas cookers by elderly women (older than 65 years) who may be more susceptible to the harmful effects of indoor air pollutants because they spend a greater proportion of their time at home. A total of 560 elderly women living in the Krakow city center were included in the survey. The survey data were collected using standardized interviews dealing with coughing; phlegm production; dyspnea on effort; past chest illnesses diagnosed by a doctor; smoking habits; education; socioeconomic conditions; the type of heating system in the household; passive smoking; the type of cooking oven; the average time spent daily cooking meals; and the proportion of time spent daily in the kitchen and other rooms of the household. In all respondents, lung function was tested with a Vitalograph spirometer. The relative risk of chronic phlegm was strongly related to exposure duration due to cooking time. Regarding dyspnea on effort, there was an increased risk among those with longer exposure times, but the trend was not as steep as it was for chronic phlegm. The mean FEV_1 level was not related to domestic cooking time; however, the age-related FEV_1 decline coefficient was much greater in those elderly women who on average were involved in cooking activities longer.

INTRODUCTION

Although many studies have traditionally focused on outdoor air, it is now apparent that elevated air pollutant concentrations are also common in households. Numerous studies have reported elevated indoor levels of nitrogen oxides and carbon monoxide in homes with unvented gas appliances (Spengler and Sexton 1983). The evidence that homes with gas cooking stoves have high levels of NO_2 has been demonstrated by Melia et al. (1978) and Wade et al. (1975), and it was found that peak levels over gas stoves may occasionally reach very high values and concentrations of NO_2 correlated with stove use. Speizer et al. (1980), in a large epidemiological study of about 8000 children from 6 to 10 years of age, showed that children living in homes with gas stoves had a greater history of respiratory illness before age two and small, but significantly lower levels of FEV_1 and FVC corrected for height. The effect of gas cooking exposure on the prevalence of respiratory symptoms and diseases in children has also been reported earlier by Melia et al. (1977, 1978).

Studies with adult subjects on health effects of unvented gas appliances indoors give conflicting results. Keller et al. (1979a, 1979b) were not able to demonstrate the association between the use of gas for cooking and respiratory illness. Helsing et al. (1982) showed that in nonsmoking white adults, the use of gas for cooking was associated with a significantly increased frequency of cough and a significantly greater percentage of people with impaired ventilatory function. Jones et al. (1983) found a small, but significant, association between low FEV_1 and the use of gas for cooking in a population of nonsmoking women. Fisher et al. (1985), measuring exposure to NO_2 and tobacco smoke in homes, found a statistically significant negative association between

pulmonary function levels and exposure to NO_2 in nonsmoking, but not smoking women.

The purpose of the present study was to assess the effect of indoor air pollutants resulting from the use of gas cookers by elderly women, who tend to spend a greater proportion of time in their homes. The results reported here were obtained as part of a large cross-sectional study on health effects of the environment on the elderly. The special emphasis here was on respiratory diseases and lung function.

MATERIALS AND METHODS

A total of 560 elderly women took part in the pilot survey on the health status of the elderly in Krakow. The subjects studied came from a random sampling of city center residents above 65 years of age. Data on respiratory problems were collected from interviews of respondents conducted by specially trained interviewers. The questionnaire used in the field study was based on the one developed by the Medical Research Council in Great Britain (1966). The questionnaire included information on coughing; phlegm production; dyspnea on effort; past diseases; smoking habits; education; socioeconomic conditions; the type of heating system in the household; the type of cooking stove used; and the average time spent daily cooking meals. Chronic cough or chronic phlegm was diagnosed in persons who reported the symptoms occurring usually during the day or night at least over three consecutive months. Dyspnea on effort was diagnosed in respondents who confirmed they were troubled by shortness of breath when climbing one flight of stairs and needed to stop for breath. All persons interviewed were invited to the field study medical center for spirometric testing with a Vitalograph nondigital vedge spirometer. Each person examined repeated the maximal forced expiration effort five times, and the highest tracing was selected to estimate FEV_1. The poor quality traces of 36 subjects have been discarded from the analysis.

RESULTS

In total, the final analysis covered 524 women with technically good spirometric tracings. Among respondents, there were 484 persons who used gas cookers and only 40 persons who used coal and/or electric kitchen stoves for preparing meals.

The main part of the analysis has been focused on the group using the gas cookers, since the group using alternative cookers did not include sufficient numbers. The analysis was concerned with self-reported chest symptoms and lung function related to the duration of cooking. The duration of exposure to indoor air pollutants associated with domestic cooking was divided into three categories: a) short exposure (less than 2 hours daily, b) medium exposure (two to three hours daily), and c) long exposure (more than three hours daily). The exposure-effect relationship analysis has been carried out in two strata (nonsmokers and current smokers). In the assessment of the relative risk ratio allowing for smoking, the Mantel-Haenszel method was used (Kleinbaum et al. 1982).

Tables 1 and 2 present the data on chronic cough and phlegm related to exposure duration. One can see that relative risk of chronic cough due to exposure is more than two times higher in those women who reported medium or long exposure to cooking (Table 1). The effect of the duration of cooking was independent from smoking. The relationship

Table 1. Relative risk (RR) of chronic cough due to duration of exposure among elderly women using gas cookers.

	Duration of exposure		
	short	medium	long
Non smokers			
Cases (chronic cough)	12	4	4
Controls (no symptoms)	335	38	47
Current smokers			
Cases (chronic cough)	3	1	1
Controls (no symptoms)	28	6	5
RR adjusted to smoking	1.00	2.66	2.27

X (M-Ext) = 1.898 $p < 0.05$

Table 2. Relative risk (RR) of chronic phlegm due to duration of exposure among elderly women using gas cookers.

	Duration of exposure		
	short	medium	long
Non smokers			
Cases (chronic phlegm)	9	3	7
Controls (no symptoms)	338	39	44
Current smokers			
Cases (chronic phlegm)	1	2	0
Controls (no symptoms)	30	5	6
RR adjusted to smoking	1.00	3.75	5.38

X (M-Ext) = 3.407 $p < 0.05$

between chronic phlegm and exposure time was more strongly pronounced (Table 2). When compared with the reference group (short exposure), women declaring long exposure time (more than three hours daily) had relative risk of 5.4, and those with medium exposure of 3.8. In this analysis, the effect of smoking was taken into account, and relative risk estimates were adjusted for smoking habits.

In regard to dyspnea on effort, there was an increased risk for those with longer exposure, and the trend of relative risk after correction for smoking was similar to that observed for chronic cough (Table 3).

No significant association between lung function level and the exposure index was found. The mean FEV_1 values of the group with long exposure were slightly lower but not statistically significant. There was a shift to lower values of FEV_1 in smokers, but again the effect of cooking duration did not appear to be meaningful.

FEV_1 level depended significantly on age, height, and smoking habits (Table 4). Current smokers had, on average, FEV_1 levels that were lower by about 130 mL when compared with FEV_1 levels of nonsmokers. Other possible confounders, like passive smoking, respiratory symptoms, and educational level, appeared to have no impact on lung function. When the regression analysis of FEV_1 based on age and height for nonsmokers was carried out separately for short daily cooking time and medium or longer exposure time (Table 5), it appeared that the regression coefficient of FEV_1 with age in the latter group was nearly four times higher (-0.043 vs. -0.013) and statistically significant. This may suggest that in persons involved daily in cooking activities over longer time periods, the estimated FEV_1 decline rate with age is 43 mL/year, while the corresponding rate for those who cook less is 13 mL/year.

Table 3. Relative risk (RR) of dyspnea on effort due to duration of exposure among elderly women using gas cookers.

	Duration of exposure		
	short	medium	long
Non smokers			
Cases (dyspnea on effort)	39	8	10
Controls (no symptoms)	308	34	41
Current smokers			
Cases (dyspnea on effort)	4	1	1
Controls (no symptoms)	27	6	5
RR adjusted to smoking	1.00	1.79	1.87

X (M-Ext) = 1.933 $p < 0.05$

Table 4. Multiple regression of FEV_1 on age, height and other predictor variables in elderly women.

Predictor variables	Coefficient	SE
Age (y)	-0.019**	0.004
Height (cm)	2.916**	0.238
Smoking	-0.129*	0.063
Passive smoking	0.039	0.035
Chronic cough	0.088	0.099
Chronic phlegm	0.149	0.102
Dyspnea on effort	0.032	0.038
Education level	0.004	0.012
Intercept	-1.603	-

* Significant at < 0.005 R = 0.469
** Significant at < 0.0001

Ratings:
For the categorical variables like smoking, passive smoking, chronic cough, chronic phlegm, dyspnea on effort: no = 0, yes = 1
For educational level: elementary school = 1, high school = 2, technical college = 3, university = 4.

Table 5. Regression of FEV_1 on age and height in two groups of elderly women differing in daily cooking activities.

	Daily cooking time	
	short	medium or longer
Age (years)	-0.011 (0.004)*	-.044 (0.011)*
Height (cm)	2.770 (0.422)*	3.585 (0.756)*
Constant	-1.941	-0.766
R	0.453	0.560

* Standard errors.

DISCUSSION

In this analysis an association has been found between the duration of time spent cooking meals using a gas stove and self-reported chronic chest symptoms. No association between exposure to indoor air pollutants and ventilatory lung function level. The impact of confounders like smoking habits possibly affecting the observed association between cooking time and respiratory symptoms has been controlled in the analysis; other confounders like socioeconomic status, the type of heating system in the household, and passive smoking, could not have biased the results, since these confounding variables were rather evenly distributed over the exposure categories.

In this study of the health consequences of exposure to gas combustion products, exposure was clas-

sified simply as "short" versus "long" gas cooking time. There may be some doubts on the discriminating power of such an exposure classification in health effect studies of indoor air pollutants since "gas cooking homes" have a wide range of pollutant concentrations. This point is strongly supported by the data of Remijn et al. (1985), who found, for example, that an estimation of historical exposure to indoor NO_2 on the basis of only house characteristics is inaccurate. The authors even showed that residents of houses in which high NO_2 concentrations were measured in the kitchen tended to spend less time in the kitchen. Therefore, kitchen activities may not be a reliable measure for general indoor air pollutant exposure. However, this study shows a clear dose-response relationship between chronic chest symptoms and time spent in the kitchen cooking meals, indicating that this variable has rather good discriminatory power and classifies the respondents reasonably well with respect to the outcome variables. The most striking differences between exposure groups have been found for chronic phlegm; this difference is quite convincing because nitrogen oxides and other combustion gases develop an irritant action on the bronchial tree. A smaller difference between groups has been found in respect to chronic cough and dyspnea on effort.

Dyspnea on effort is of major interest because it is the most important symptom resulting from disabilities of pulmonary origin. There may be some uncertainty as to what extent the observed excess in dyspnea symptoms among elderly women, exposed to longer cooking times can be attributed to lung impairment. In fact, the symptoms may also be caused by such other factors as like cardiovascular diseases. Measuring the extent to which dyspnea on effort can be attributed to lung damage or cardiac failure in the elderly is very difficult, and a clear answer cannot be given from the data. This issue must be explored further using other approaches. Since the results show no significant, higher prevalence of cardiovascular disease diagnosed by physicians among persons with longer exposure, a possible conclusion is that the observed excess in dyspnea on effort presumably is related to respiratory impairment due to gas cooking.

Keeping in mind the higher prevalence of dyspnea on effort in elderly women with long periods of cooking activity, consistent changes in lung function could have been expected in the persons studied. Ventilatory function levels, however, were not different between the groups with shorter and longer cooking exposure. The data could not confirm any impairment of lung ventilatory function measured by FEV_1, but impairment may happen if the pathological changes were pronounced mainly in the small bronchial tree. In addition, in interpreting lung function level using the cross-sectional approach, one has to keep in mind that the level of a given variable (FEV_1) is the consequence of different individual initial values and subsequent decline rates with age. Despite the lack of difference in FEV_1 levels between exposure groups the data disclosed that estimated decline rates of FEV_1 with age are faster in those nonsmoking women who cooked longer daily. This finding suggests that greater lung function loss with age in those with more exposure must be confirmed in subsequent study, in which baseline levels of FEV_1 are taken into consideration.

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AN EXPERIMENTAL STUDY ON HUMAN SENSATION TO AIRFLOW IN NATURALLY VENTILATED ROOMS

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During two summers, the authors conducted experiments on the effect of cross-ventilation, the most traditional and popular passive cooling means in Japan, on thermal sensations of people. Five male and five female subjects of college age were exposed to airflow for 60 to 90 minutes in the cross-ventilated room of the dwelling units and voted on their thermal sensations, including comfort sensation and airflow sensation. Airflow sensation of the whole body has a high correlation with comfort sensation, especially for females: airflow plays an important role in promoting the thermal comfort of people. A comparison between males' and females' frequency in changing their votes on comfort sensation implies that females are thermally more sensitive than males are. Airflow sensation of the whole body is related to airflow velocity. Females recognize low airflow more sensitively than males do. Among the parts of the body, airflow sensation at the shanks facing to the wind has the best correspondence with that of the whole body. Sensations about airflow speed, strength, and fluctuation have high correlations with each other and airflow sensation of the whole body. These three airflow characteristics influence comfort sensation in a cross-ventilated room. The relationship between temperature sensation resulting from airflow with air temperature shows a different tendency by two ranges of airflow velocity; voting temperature sensation in the cool range requires lower air temperature for the low velocity range (less than 1 m/s) than for the high velocity range (over 1 m/s).

INTRODUCTION

From ancient times Japanese people have enjoyed the wind both outdoors and indoors, especially for cooling against the hot, humid summer. They distinguish between cross-ventilation for cooling their bodies from general ventilation for exchanging air and maintaining indoor air quality. Cross-ventilation is called *Tsuhfuh* which means wind passing through the rooms. Japanese love indoor airflow, while western people rather dislike it and call it a draft. This is due to differences in living customs, as well as in climate.

The Japanese sit on *Tatami* floors in their houses. Most room openings are from the floor almost up to the ceiling to allow wind into the room. As a matter of course, floor to ceiling airflow induced by natural wind is fully turbulent. Thus, people can enjoy the fluctuant wind, even indoors.

Figure 1 compares the climate between representative cities in Japan (Tokyo and Aomori) and in Europe (Berlin) by climogram with air temperature on the abscissa and relative humidity on the ordinate. It shows that the Japanese summer is much more humid and hotter than that in Europe. Under these conditions, airflow is favorable as it promotes heat loss from the human body not only by convection but also by evaporation. On the other hand, Berlin is colder in winter than Tokyo by about five degrees; since the wind increases the cold, this might explain why western people enjoy the wind less than the Japanese.

Thus indoor airflow has often been researched in Europe and America as discomfort (Fanger and Christensen 1986; Houghton et al. 1938), a condition which should be reduced as much as possible, especially in air-conditioned rooms. Air-conditioning systems originated in the U.S. and Europe and have become popular in Japanese residences as well as office buildings. As a result, cross-ventilation has become irrelevant as a cooling means.

Since the oil crisis, however, natural ventilation has been considered even in the West, though mainly as a strategy for energy conservation (Arens et al. 1984; Ashley and Sherman 1984; Chandra and Kerestecioglu 1984; Kammerud et al. 1984; Mathews 1986).

Considering the above-mentioned differences between Japan and the West, it is important to examine airflow in a cross-ventilated room from the viewpoint of thermal comfort. Therefore, during two summers, the authors carried out experiments on the effect of cross-ventilation on human thermal sensations in dwelling units, using a cross-ventilated room and human subjects. This paper examines airflow sensation, which is considered to be most characteristic among all thermal sensations sampled.

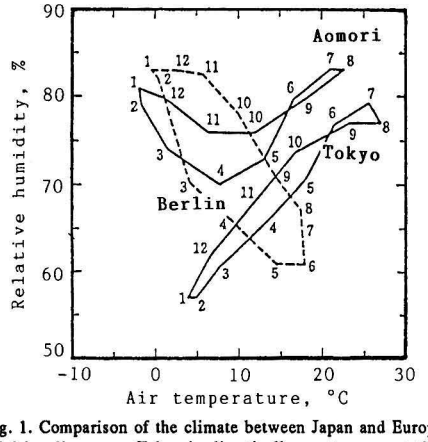


Fig. 1. Comparison of the climate between Japan and Europe (Berlin) by climogram. Tokyo is climatically most representative of the Pacific coastal area of Japan. Aomori is on the northern most part of Honshuh, the main island of Japan, with snowfall sometimes over 1 m in depth in winter.

EXPERIMENTAL PROCEDURES AND CONDITIONS

The experiments were conducted from June through August 1984 and 1985 at two dwelling units on the sixth or seventh floor of ten-story apartment houses in Fukuoka (see Fig. 2). The dwellings have entrances on the north and balconies on the south, and so do not get direct sunshine.

As listed in Table 1, five male and five female subjects of college age were used. DuBois area is calculated by the equation corrected for Japanese by Takahira. Subjects wore experimental clothing ensembles of 0.3 clo. Each subject but C, E, P, and T was tested four times each in 1984 and in 1985.

The experiments consisted of 64 runs. The schedule is shown in Fig. 3. After a subject was sedentary in the experimental room with all the windows closed for 30 minutes, the entrance door and doorway to the balcony behind the subject were opened for 60 or 90 minutes. During the experiment the subject faced airflow induced by the northern sea breeze, the prevailing wind in the day during the summer season of Fukuoka. The subjects voted comfort sensation by

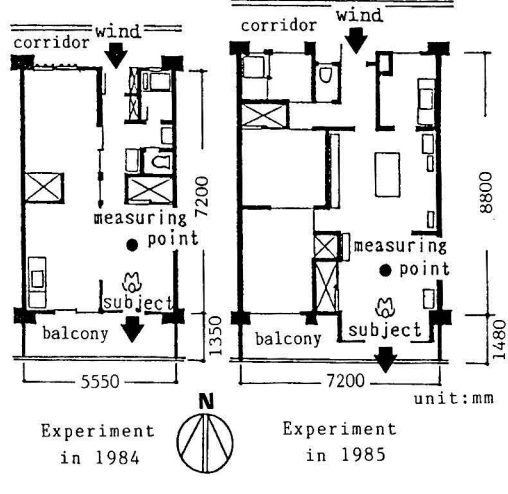


Fig. 2. Description of the corridor-type dwelling units where the experiments were conducted in 1984 and 1985. During the experiments, the windward entrance door and the leeward doorway to the balcony behind the subject were opened for passing wind.

Table 1. Description of subjects. Skin surface area is calculated by corrected DuBois' equation, $A_D=0.007246xW^{0.425}xH^{0.725}$ (in unit shown in the table), by Takahira for Japanese.

Male					Female				
Subject	Age year	Height cm	Weight kg	Area m^2	Subject	Age year	Height cm	Weight kg	Area m^2
A	21	168	58	1.67	P[a]	28	160	51	1.53
B	20	172	49	1.58	Q	21	163	58	1.64
C[a]	20	170	65	1.76	R	19	154	44	1.40
D	22	176	70	1.87	S	19	166	58	1.66
E[b]	21	173	67	1.82	T[b]	19	158	53	1.54
Clothing (0.3clo)		brief short shirt short pants			Clothing (0.3clo)		panties brassiere short blouse skirt		

a) Only in 1984. b) Only in 1985.

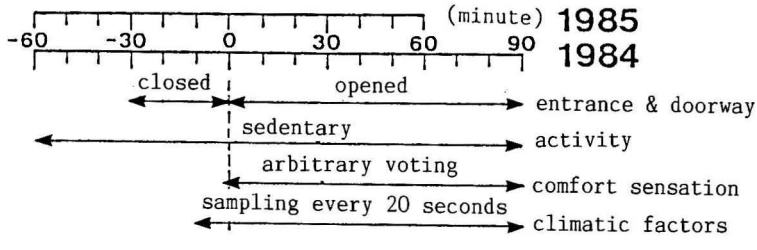


Fig. 3. Schedule of a run of the experiment. Exposure time is different between 1984 and 1985. A subject votes comfort sensation by pushing a button just when he or she feels that it has changed and then votes the other thermal sensations orally.

pushing a button just when they felt that it had changed and then orally voted the other thermal sensations. It took 30 seconds to 1 minute for the subject to complete the voting. The subject rested until they felt the comfort sensation change and voted again.

Thermal sensations other than comfort sensation are: airflow sensation, temperature sensation, wetness sensation, and radiation sensation of the whole body and at four local parts of the body, i.e. face, chest and abdomen, thighs, and shanks, and six kinds of airflow sensation. Table 2 shows category scales of comfort sensation, airflow sensation, and six kinds of airflow sensation for analysis in this paper.

Climatic data were sampled by a data-logger with an interval of 20 seconds which was decided in consideration of the performance of the sampling system and a third unit of one minute. Air and globe temperatures were measured by a thermo-couple 0.1 mm in diameter; relative humidity by hygrometer with high-polymer elements; and airflow velocity by non-directional, thermal-type anemometer at the height of 120 cm (equivalent to the face of the seated subject) and 1 m windward from the subject. As described in the Introduction, there is barely a vertical profile of temperature or velocity with fully turbulent airflow in the experimental rooms. The authors' previous measurements show that indoor air temperature becomes almost uniform both vertically and horizontally as soon as windows and doors are opened for cross-ventilation.

Figure 4 shows environmental conditions during the experiments by relative frequency distributions of measured values of air temperature, air velocity, globe temperature, and relative humidity with mean values in terms of $\overline{t}_a$, $\overline{v}$, $\overline{t}_g$, and $\overline{rh}$, respectively. The

Table 2. Category scales of comfort sensation, airflow sensation and six kinds of feeling of airflow.

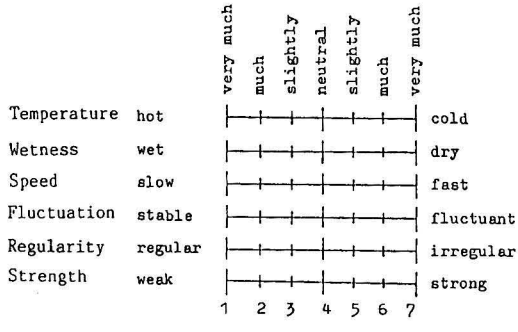
Comfort Sensation

1 very uncomfortable	5 slightly comfortable
2 uncomfortable	6 comfortable
3 slightly uncomfortable	7 very comfortable
4 neutral	

Airflow Sensation

1 insensible	4 sensible
2 very slightly sensible	5 much sensible
3 slightly sensible	6 very much sensible

Six Kinds of Airflow Sensation



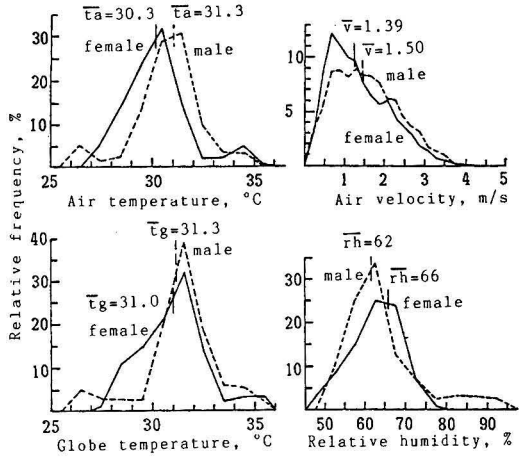


Fig. 4. Environmental conditions of the experimental rooms by relative frequency distributions of air temperature, air velocity, globe temperature, and relative humidity, with mean values in terms of $\bar{t}_a$, $\bar{v}$, $\bar{t}_g$, and $\bar{rh}$, respectively, for male (broke n li ne) and female (solid line). Number of sampling data is about 7900.

graphs are depicted separately for male (broken lines) and female (solid lines), as most of the data are analyzed for each sex in this paper. More than 80% of the experiments were conducted under warm conditions with air temperature higher than 28°C and good airflow conditions higher than 0.60 m/s. Differences of globe temperature and air temperature are less than one degree on average, which implies that radiation has little influence on subjects in the room.

Averages of turbulence intensity which is calculated every five minutes from measured data of air velocity are 23.8% and 37.2% with standard deviations of 9.6% and 10.1% in 1984 and 1985, respectively. This supports the statement that airflow in the experimental room is fully turbulent.

AIRFLOW SENSATION OF THE WHOLE BODY

Figure 5 shows frequency distribution of the vote of airflow sensation of the whole body for each subject. Sampling number, N, is different for each subject, as each sensation was sampled when the comfort sensation had changed. So N means how frequently the subject changed its comfort sensation vote. There is a remarkable difference, particularly between males and females: female subjects more frequently changed

their vote on comfort sensation than males did. This might imply that females are thermally more sensitive than males are.

The relationship between comfort sensation and airflow sensation is shown for males and females in Fig. 6. Both sensations are correlated. The more sensitively a subject notices airflow, the more comfortable he or she feels. This indicates that airflow induced by cross-ventilation is important for improving comfort sensation of people in a room without air-conditioning. Considering higher correlation coefficients for females than for males, this might be more applicable to females than to males. That is, females find airflow more comfortable in a cross-ventilated room than males do.

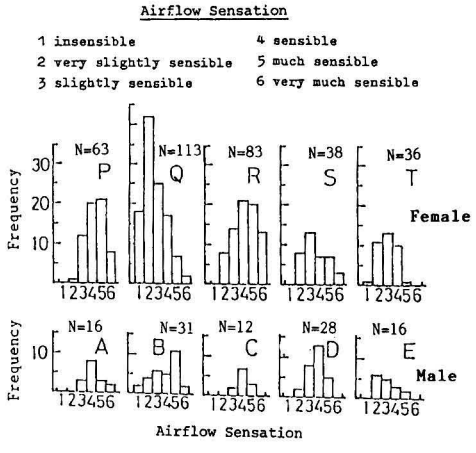


Fig. 5. Frequency distributions of the vote of airflow sensation of the whole body for each subject. N is the number voting. Upper subjects are females, and lower ones are males.

Figure 7 relates airflow sensation to airflow velocity for each subject and for males and females in total. Hereafter, air velocity or air temperature corresponding to each vote on airflow sensation, etc., is a value averaged in one minute after comfort sensation changes are voted, i.e. a mean value of three successive sampling data. This paper deals with data for each vote to show that sensations vary widely even under similar conditions and does not give an averaged value for each level of sensation which would give a higher correlation. Large differences of air velocity for a category level of the sensation shows that a person does not always make the same response to the same conditions, especially under these uncontrolled and unsteady conditions. In that sense, there is a high correlation for each female subject. Subjects P and Q, who changed their votes frequently, show the highest correlation and are sensitive to the change of airflow velocity. On the other hand, there is a considerable difference among male subjects, with little change of their votes (except

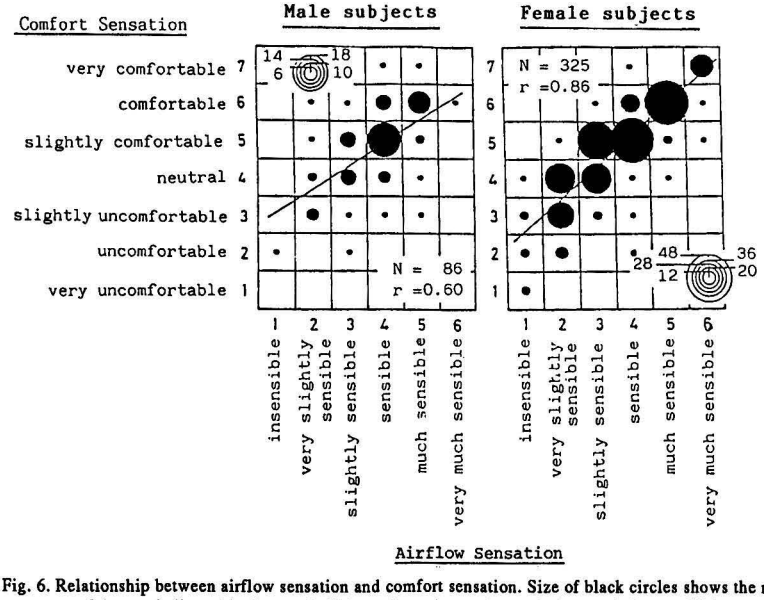


Fig. 6. Relationship between airflow sensation and comfort sensation. Size of black circles shows the number of data as indicated in the graph. N is total number voting and r is correlation coefficient.

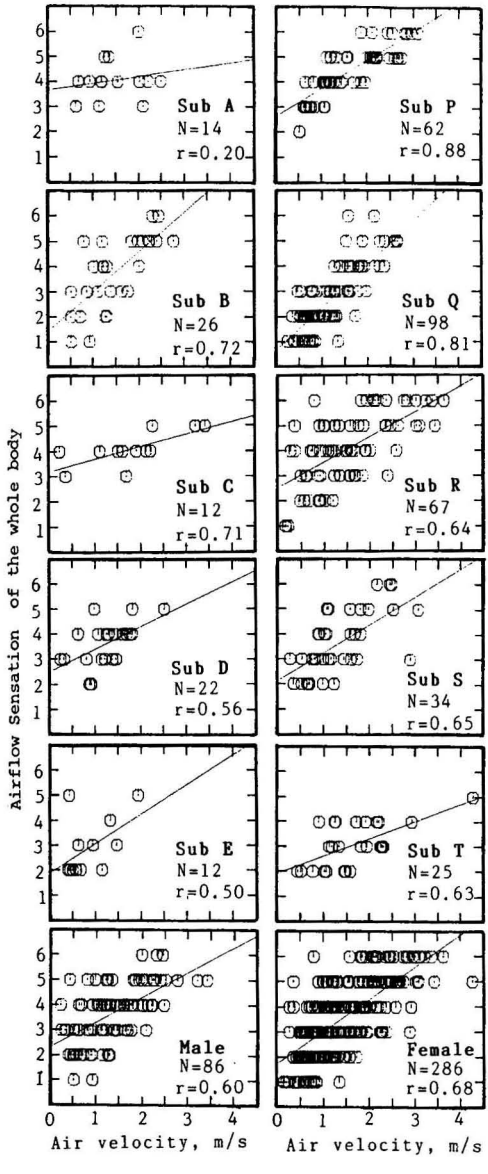


Fig. 7. Relationship between airflow velocity and airflow sensation of the whole body for each subject and for males and females in total on the bottom. N is number voting and r is correlation coefficient.

subject B). Correlation for males in total is, however, as high as for females in total.

The cumulative frequency distributions of airflow velocity for each level of airflow sensation are

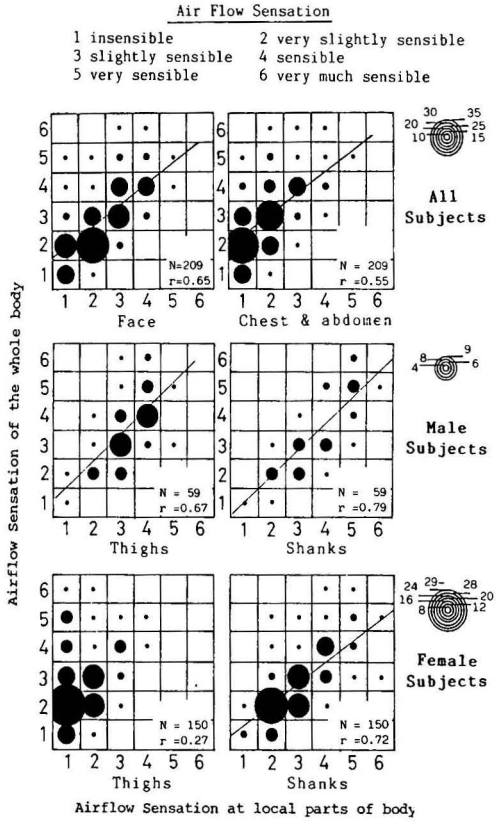


Fig.9. Comparison of airflow sensation of the whole body with that of the local parts of the body. Size of black circles shows the number of data as indicated on the right side. N is total number voting and r is correlation coefficient.

depicted in Fig. 8. In the low velocity range of less than 1 m/s, the curves of "1 insensitive" and "2 very slightly sensitive" overlap for male subjects, while clearly distinguished for females. That is, females are more sensitive to low airflow than males are. The curves of distribution are clearly distinguished except for that part. The table on the top of Fig. 8 gives 50 percentiles of each level of airflow sensation for males and females. There is little difference in the median between males and females. It is interesting that the medians of "insensitive" are larger than 0.5 m/s, which would be abominable as a cold draft in an air-conditioned room.

50 percentiles of airflow velocity for each level of airflow sensation

level	1	2	3	4	5	6
female	0.6	0.9	1.1	1.4	2.0	2.4m/s
male	0.7	0.7	1.1	1.4	2.0	2.3m/s

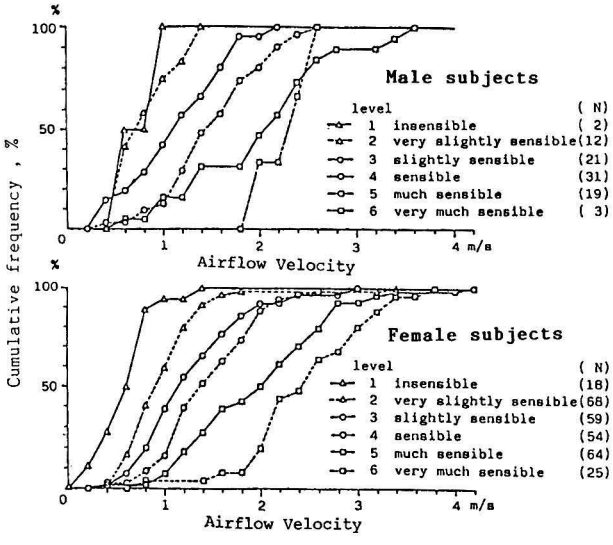


Fig. 8. Cumulative frequency distribution of airflow velocity for each level of airflow sensation of the whole body.

AIRFLOW SENSATION OF THE LOCAL PARTS OF THE BODY

Figure 9 compares airflow sensation between the whole body and the local parts of the body. The diagrams for thighs and shanks are shown separately for males and females, but those for face, chest, and abdomen are composed of data of all subjects because there is hardly any difference between male and female. The size of the black circles shows the number of data as indicated on the right side.

Shanks have the best correspondence to the whole body for either male or female and are considered the most sensitive part of the body. Shanks are exposed, facing airflow, and are more peripheral parts of the body. Sensation of thighs is considerably different between male and female, attributed to differences in clothing. The male in short pants, exposing his thighs, is sensitive to airflow at those parts, while the female, covering her thighs in a skirt, is almost insensitive. The face is sensitive to airflow and is considerably correspondent to the whole body. The chest and abdomen covered by clothing has few "sensitive votes" and does not have high correlation with the whole body.

SENSATION OF AIRFLOW

Figure 10 shows frequency distributions of the vote on six kinds of sensation, i.e. temperature, wetness, speed, fluctuation, regularity, and strength of airflow for males and females. Temperature, speed, fluctuation, and strength sensations range widely, but wetness sensation concentrates in the wet range of 4 to 7 and regularity sensation in the irregular range of 4 to 7.

A correlation matrix between airflow sensation of the whole body and six sensations of airflow is given for males and females in Table 3. Correlation coefficients larger than 0.75 are shaded. Regularity sensation has little relationship with the others, attributed to concentration into the irregular range as mentioned above. Three sensations of speed, strength, and fluctuation of airflow are highly related to airflow sensation of the whole body and to each other. Considering Fig. 6, this suggests that these three

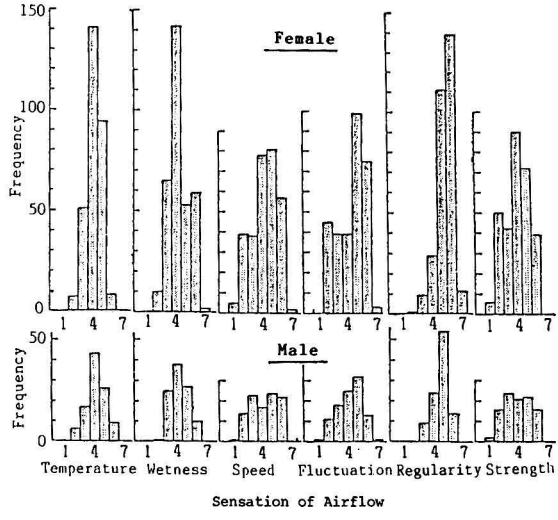


Fig. 10. Frequency distributions of the vote on six kinds of sensation, i.e., temperature, wetness, speed, fluctuation, regularity, and strength of airflow. Total numbers voting for each sensation are33 and 103 for female and male, respectively.

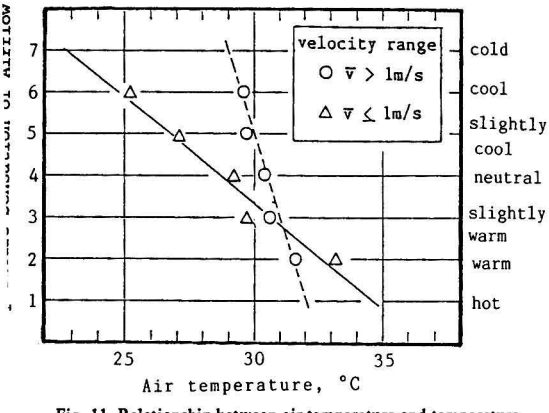


Fig. 11. Relationship between air temperature and temperature sensation of airflow for two ranges of airflow velocity. Air temperature is a mean value over all the voting for each category level.

characteristics of airflow influence comfort sensation in the cross-ventilated room.

Figure 11 shows by two ranges of airflow velocity the relationship between temperature sensation of airflow and air temperature averaged over all data for each level of the sensation. There is a good correspondence between air temperature and temperature sensation for either velocity range. Voting temperature sensation in the cool range requires an air temperature of less than 27°C for low velocity range within 1 m/s, but is satisfied with as high as about 29.5°C for high range over 1 m/s. However, crossing of the two lines over 30°C implies that ranging air velocity might not have meaning under such hot conditions. That is, air velocity has greater influence on temperature sensation in the lower temperature range than in the higher range.

Wetness sensation was not highly related to relative humidity, partly attributable to the narrow range of its vote.

Speed and fluctuation sensations are correlated with mean velocity for males and females in Figs. 12 and 13, respectively. For mean velocity over 2 m/s, either steady range of fluctuation sensation or slow range of speed sensation is rarely voted. In attempting to relate fluctuation sensation to both turbulent velocity and turbulence intensity, low correlation coefficients of about 0.30 were found, contrary to expectation. Less than 20 seconds of sampling time might be required for dealing with turbulence.

SUMMARY AND CONCLUSION

According to the experiments conducted, human sensation to airflow in a cross-ventilated room is summarized as follows.

Female subjects more frequently changed their vote on comfort sensation than males did. This might imply that females are thermally more sensitive than males are.

Airflow sensation of the whole body is related to comfort sensation: airflow plays an important role in

Table 3. Correlation matrix between airflow sensation of the whole body and six kinds of feeling of airflow. Coefficients larger than 0.75 are shaded.

		Airflow Sensation	Sensation of Airflow: Temperature	Wetness	Speed	Fluctuation	Regularity	Strength
Airflow Sensation			0.44	0.44	0.82	0.78	0.33	0.79
Sensation of Airflow	Temp.	0.36		0.44	0.41	0.41	0.05	0.40
	Wetness	0.42	0.59		0.41	0.44	0.11	0.48
	Speed	0.76	0.27	0.41		0.82	0.30	0.85
	Fluct.	0.77	0.24	0.34	0.75		0.40	0.83
	Regul.	-0.03	-0.32	-0.34	-0.14	-0.00		0.29
	Strength	0.76	0.37	0.44	0.84	0.80	-0.15	

male subjects / female subjects

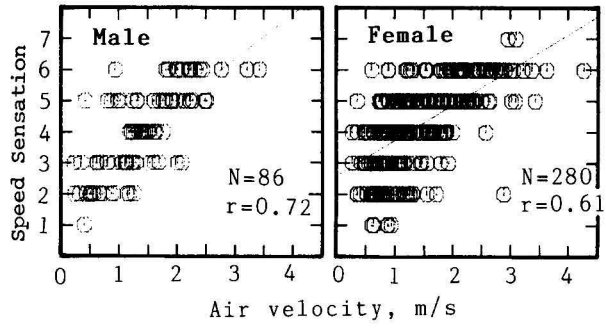


Fig. 12. Relationship between air velocity and speed sensation of airflow for male and female. N is total number voting and r is correlation coefficient.

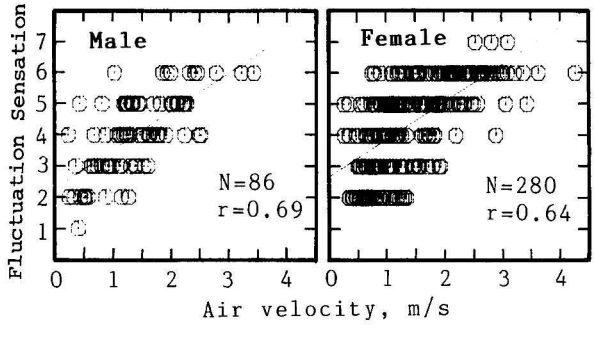


Fig. 13. Relationship between air velocity and fluctuation sensation of airflow for male and female. N is total number voting and r is correlation coefficient.

promoting thermal comfort of people. Females feel airflow is more comfortable than males do. Airflow sensation of the whole body is closely related to airflow velocity. Females recognize low airflow more sensitively than males do.

Among the local parts of the body, airflow sensation at the shanks facing airflow have the best correspondence with that of the whole body for either female or male.

Speed, strength, and fluctuation sensations of airflow have high correlations with each other and airflow sensation of the whole body. These three characteristics of airflow influence comfort sensation.

The relationship of temperature sensation of airflow with air temperature shows a different tendency by two ranges of airflow velocity. Voting temperature sensation in the cool range requires lower air temperature for the low velocity range within 1 m/s than for the high velocity range over 1 m/s.

Fluctuation sensation of airflow is correlated with airflow velocity, but not with turbulent velocity and turbulence intensity. Shorter sampling time than 20 seconds might be required for dealing with turbulence.

The other thermal sensations, including comfort sensation and other than airflow sensation, are to be analyzed successively.

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OPERATIVE TEMPERATURE — THE MOST SUITABLE WAY FOR PRACTICAL CIVIL ENGINEERING?

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A study in dwellings in a town of 400 000 inhabitants (Bratislava, Czechoslovakia) showed that during the heating period the mean indoor-air temperature exceeds the value assumed in some of the European building codes (20°C). An analysis revealed that when planning energy-saving measures economic stimulation of users has to be considered to use all potential technical measures. A simplified comfort formula is proposed. Tables of operative temperature for an optimal domain are presented for possible combinations of clothing and activity in dwellings and office buildings.

INTRODUCTION

In Czechoslovakia (as in other countries in middle Europe) there are three different types of building codes which have an effect on the thermal state of an environment: 1) codes dealing with thermal properties of building's envelopes (building physics), e.g., CSN 73 0540, DIN 4108; 2) codes for the determination of thermal losses (heating systems), e.g., CSN 06 0210, DIN 4701; and 3) codes for the determination of thermal gains (air conditioning), e.g., CSN 73 0548. The codes in this system have something in common—every building code considers the creation of an optimal indoor climate as an automatic consequence of meeting fixed requirements on thermal properties of envelopes and considers the design of the heating or cooling power on the basis of thermal losses or gains calculations. Interiors are considered to be relatively uniform and no requirements are made on possible asymmetry. The only aid for designers in defining an "optimal" thermal state is a table of taxative specified values of "so called resulting temperature t_i" for different types of premises, which should be a very simple and fictitious, theoretical representation of the globe temperature (this is the case in the Czechoslovak code CSN 06 0210; the German code DIN 4701 uses a simple indoor-air temperature).

Measurements carried out by the Department of Building Physics (Civil Engineering Faculty of Slovak Technical University) in normal conditions in dwellings and office buildings showed that the assumption of thermal uniformity is not only inappropriate in larger spaces but it also does not apply in smaller spaces (for more references, see Piršel and Petráš 1987, Petráš and Piršel 1987, Piršel 1988). Therefore, the approach of a simple temperature criterion representing the whole indoor environment has been rejected.

There are many questions which arise when defining the interaction between economic efficiency and thermal comfort. Much of the laboratory research carried out by Nevins (1971, 1974), Rohles (1971, 1974, 1980), Gagge (1952), Fanger (1970, 1974, 1980), McIntyre (1977, 1978), Bánhidi (1980) and Jokl (1971) was concerned with the physiology of thermal sensation and acceptance in well specified experimental conditions. There is a lack of experiments in normal (daily) home and work conditions. Some interesting studies on this problem have been done recently (Auliciems and Dedear 1985, 1986). However, it is important for an engineer to know how people react when their attention is not oriented in a special way as it is in laboratory studies.

There are several approaches to designing a building's envelope and to the use of technical equipment which affects users' thermal sensations and comfort. A few of the numerous available parameters for environmental evaluation are mentioned as follows: temperature criteria such as Houghten's and Yaglou's effective temperature (ET) of the early twenties; Winslow's operative temperature (t_o) of the thirties; Yaglou's and Minard's wet-bulb-globe-temperature (WBGT) of the fifties; Gagge's new effective temperature (ET*) and his humid operative temperature (HOT) of the end of the sixties and beginning of the seventies; and Horikoshi's and Kobayashi's corrected humid operative temperature of 1985 (for a more comprehensive review, see Jokl 1971, Horikoshi and Kobayashi 1985). In 1970 Fanger proposed his sophisticated indices predicted mean vote (PMV) and predicted percentage of dissatisfied (PPD). His thermal comfort theory based on a "thermal comfort equation" enables one to predict the interaction between man and his thermal surroundings.

The advantage of the former methods is that temperature criteria are used which technicians favor; an advantage of the latter is that it tries to estimate human reaction to thermal stress from the environment. The aim of this paper is to design a simple method which can integrate the simplicity of a temperature criterion with the complexity of Fanger's thermal comfort model.

MATERIALS AND METHODS

The current study consists of temperature measurements and inquiry research in almost 500 flats in Bratislava (a town of about 400 000 inhabitants in Czechslovakia) during the 1987 heating period. The flats were chosen on a statistical basis as a representative sample of different parts of Bratislava and the time they were built. The individual period of erection represents different U-values of enveloping constructions. The experimental procedure consisted of temperature measurements in living rooms and bedrooms and a set of questions (13 prescribed and 1 free) the users were asked. These questions covered actual thermal sensation in the living room and bedroom (present experience), evaluation of the thermal state during the whole year (annual experience), clothing and ventilation habits, evaluation of the air-humidity, perceived infiltration (air movement), and also some general questions about general satisfaction with the surroundings (including the outside of the building).

The following differential psychophysical scale for the evaluation of subjective thermal sensations was used:

-3 it should be a great deal warmer;
-2 it should be warmer
-1 it should be a little warmer;
0 it is just right;
+1 it should be a little cooler;
+2 it should be cooler; and
+3 it should be a great deal cooler.

The points ±3 were considered to be unrealistic for dwellings and were rejected in the questionnaire.

Besides the aforementioned study, several experiments in dwellings and office buildings were carried out to compare three different temperature criteria: air temperature, globe temperature, and operative temperature.

Globe temperature is the temperature inside a black hollow sphere of copper-sheet with a diameter of 10 cm and an outside covering of polyurethane (see Jokl 1971—Vernon-Jokl globe).

Operative temperature is a hypothetical temperature of a radiantly black, thermally uniform enclosure in which an occupant exchanges the same amount of heat by radiation plus convection as in the actual non-uniform environment (see ASHRAE standard 55-1981).

During an experiment a room was monitored. Besides temperature and humidity measurements the predicted mean vote (PMV-index) was determined with a comfort-meter. Linear regression equations were evaluated between the PMV-index and air, globe, and operative temperature, respectively.

RESULTS

The analysis of the representative study results in Bratislava dwellings is shown in Figs. 1 through 5 (the rate which is missing to 100% represents unobtained or invalid answers). A temperature

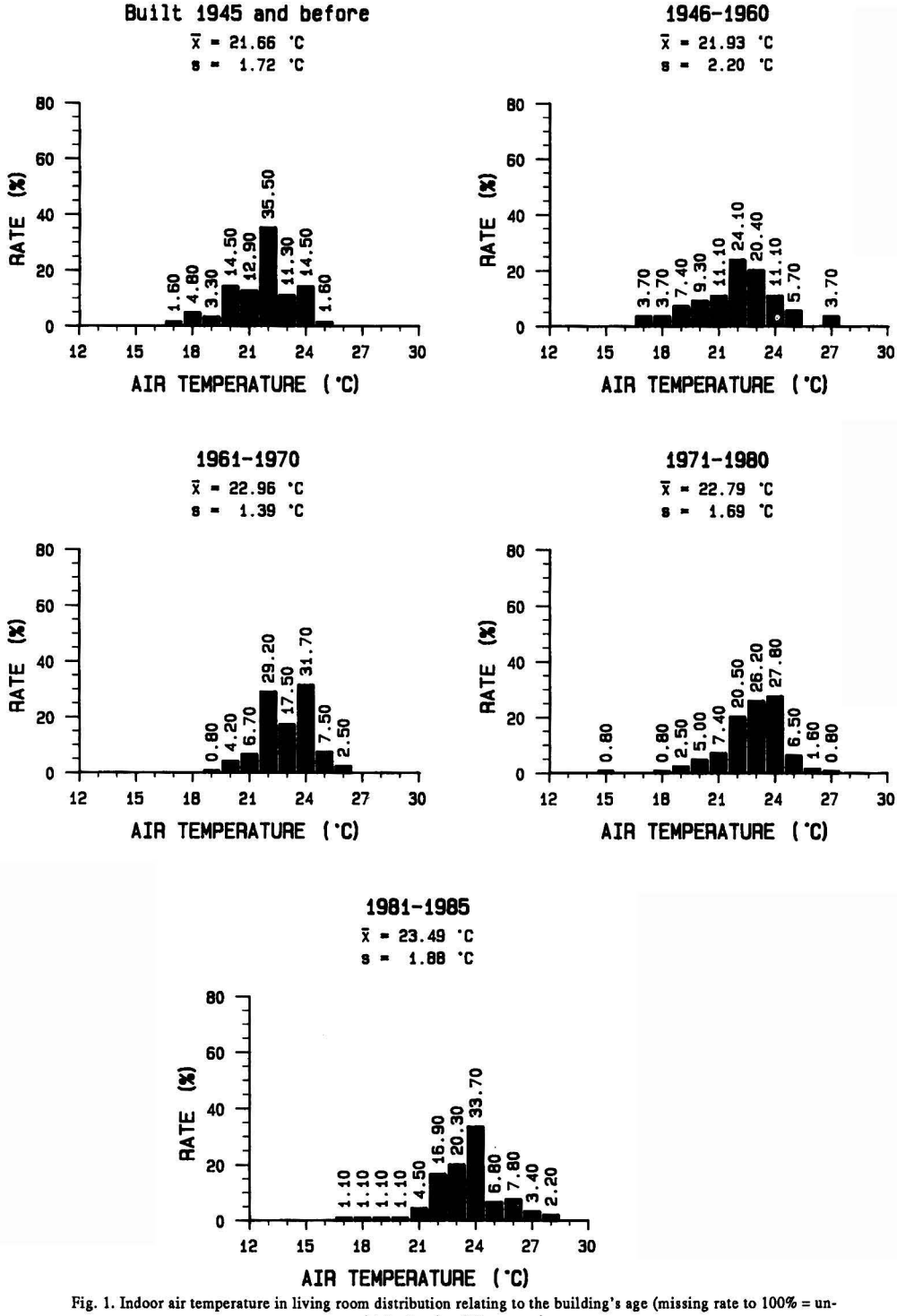


Fig. 1. Indoor air temperature in living room distribution relating to the building's age (missing rate to 100% = unobtained or invalid answers).

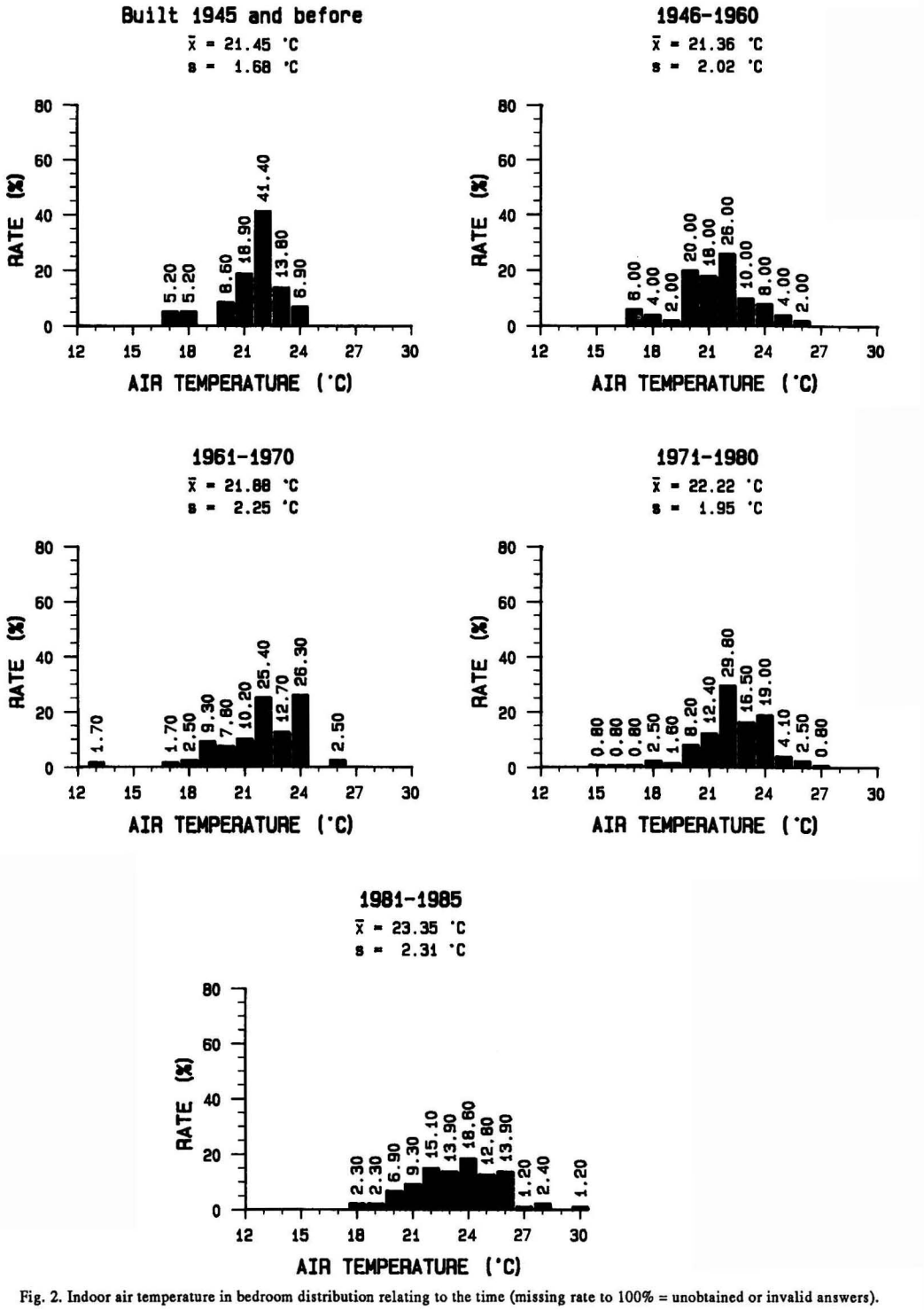


Fig. 2. Indoor air temperature in bedroom distribution relating to the time (missing rate to 100% = unobtained or invalid answers).

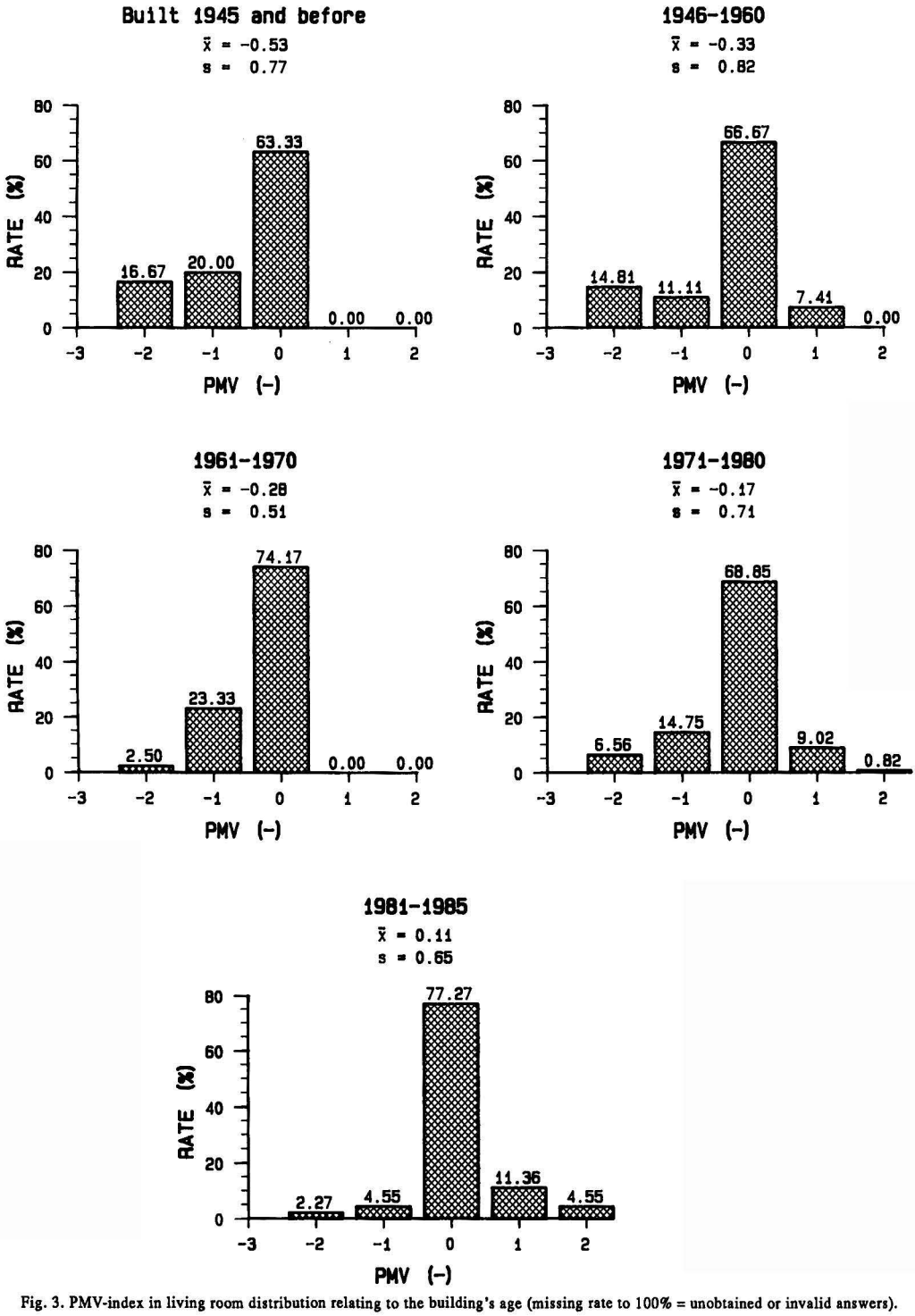


Fig. 3. PMV-index in living room distribution relating to the building's age (missing rate to 100% = unobtained or invalid answers).

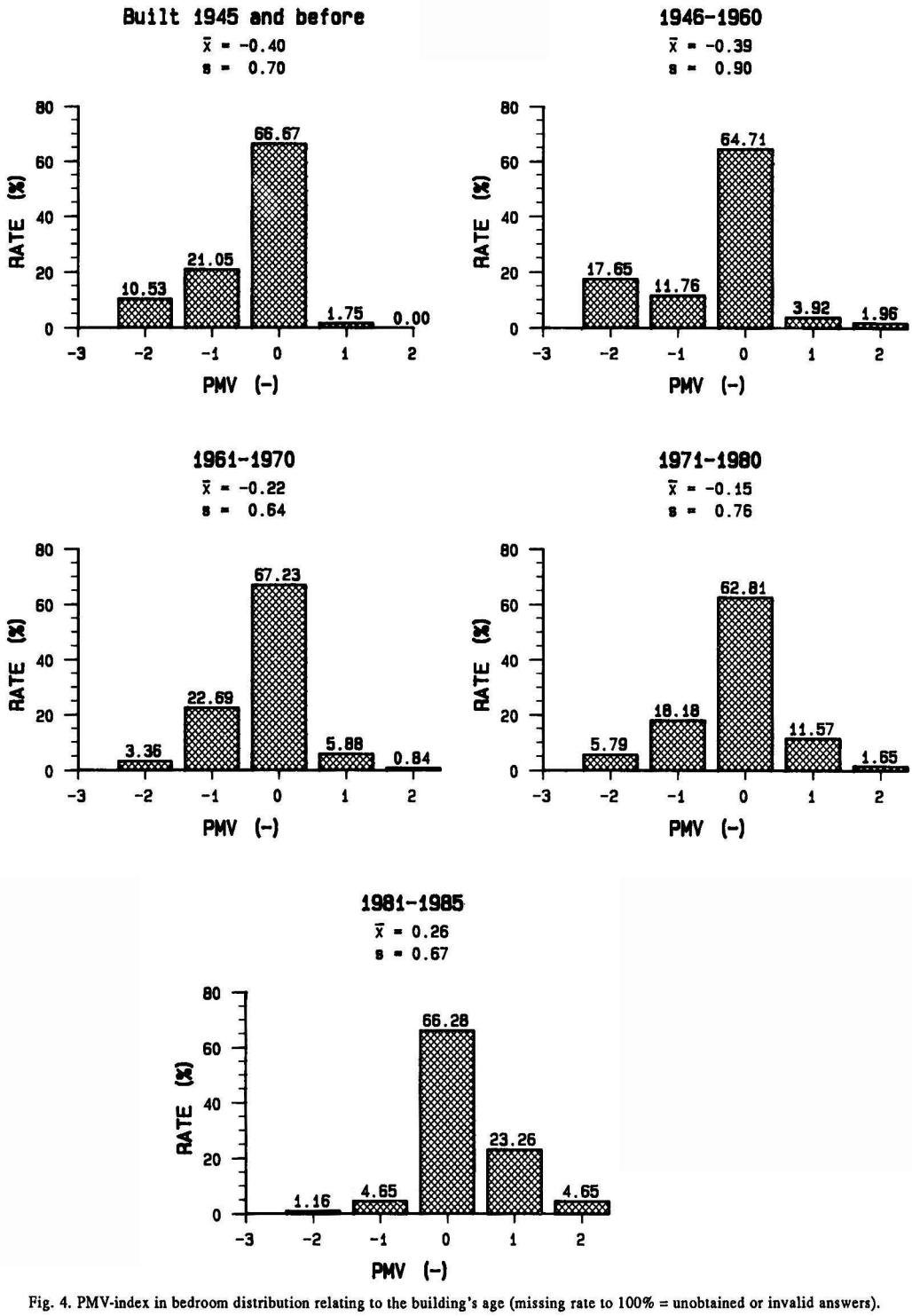


Fig. 4. PMV-index in bedroom distribution relating to the building's age (missing rate to 100% = unobtained or invalid answers).

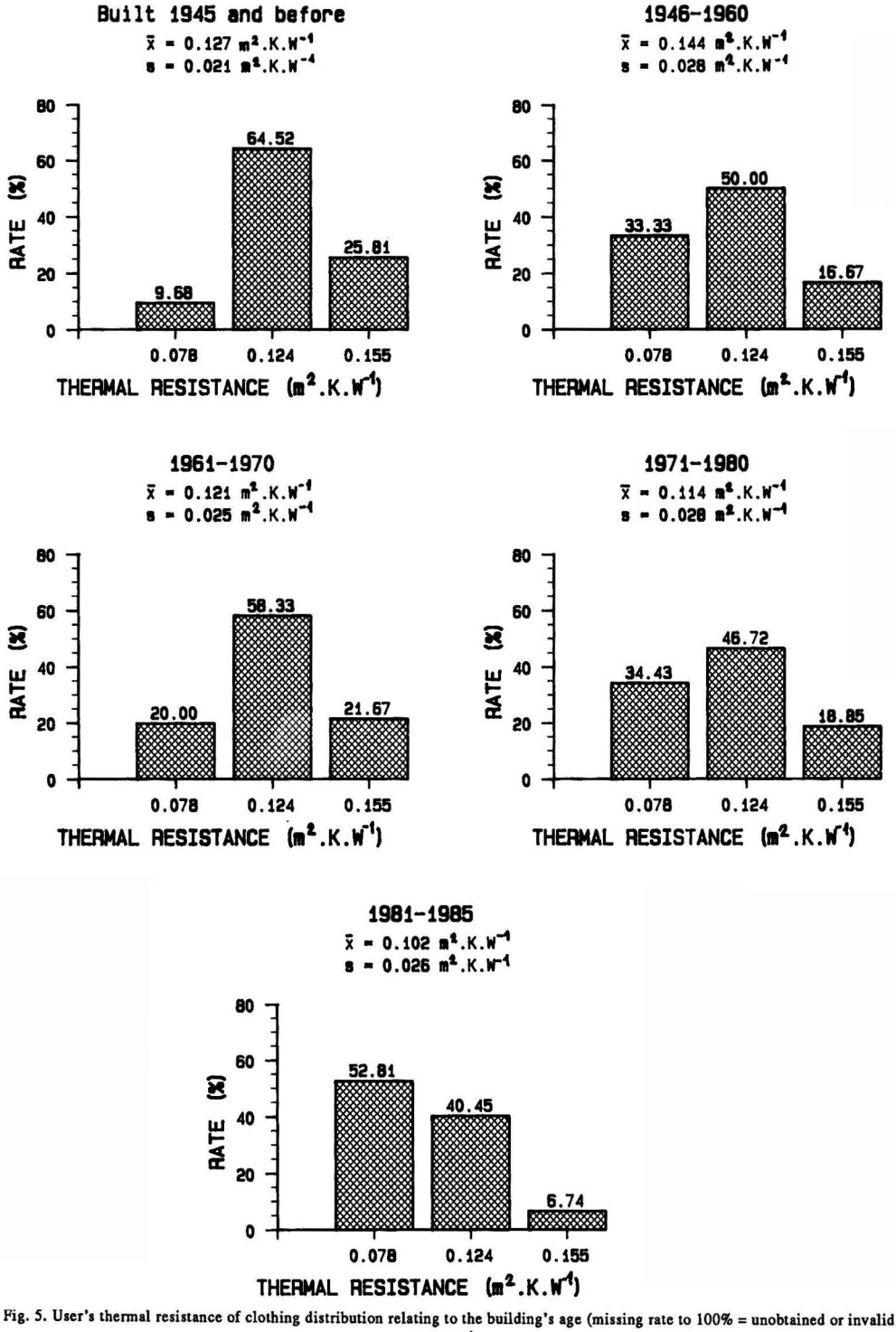


Fig. 5. User's thermal resistance of clothing distribution relating to the building's age (missing rate to 100% = unobtained or invalid answers).

distribution is shown in Fig. 1 for living rooms and in Fig. 2 for bedrooms. A tendency of rising mean indoor-air temperature with an increase in the building age was observed both for living rooms and bedrooms. However, there are some exceptions to this statement. In spite of the exceptions in mean indoor-air temperature, there are no exceptions in the mean subjective thermal sensation (see Fig. 3 and Fig. 4—subjective thermal sensation is designated as PMV). The differences between determined mean values are found to be statistically significant. The distribution of three different types of clothing is shown in Fig. 5; there was also a dependence between the time of the building's erection and the mean value of thermal resistance of clothing (0.078 m^2 K W^{-1} clothing, 0.124 m^2 K W^{-1} — summer clothing with long sleeves and without jacket or pullover, 0.155 m^2 K W^{-1} — clothing with jacket or pullover and long sleeves).

The results of the dwelling study were a little surprising as to the unexpected low mean values of thermal resistance of clothing. No mean value of the indoor-air temperature was equal or lower than the value described in the building codes (20°C). It seems that a poor economic stimulation in the newer buildings concerning heating is to blame for the high mean indoor-air temperatures. All new flats had a district heating system and the radiators were equipped with thermostatic valves, but they were rarely used. In these flats heating costs are paid on the basis of living surface or number of inhabitants in the flat.

The analysis of the results of the experiments in dwellings and office buildings showed the best correlation for measured PMV-index and the operative temperature. An example of the results is shown in Fig. 6 for standing position and in Fig. 7 for sedentary subjects, both for the thermal resistance of clothing at 0.124 m^2 K W^{-1} (long sleeves without jacket or pullover). The best consistency of regression coefficients could be observed for the operative temperature as well. On the basis of these results the operative temperature has been chosen as the most suitable checking parameter for practical civil engineering when designing dwellings and office buildings. Because humidity is always assumed to be present and does not vary much in such interiors, and since insufficient data are available on vapor permeation of clothing, the use of humid operative temperature has not been considered necessary.

POSSIBLE THEORETICAL SOLUTION

In 1970 Fanger formulated his well-known "thermal comfort equation", which could be divided into a thermal balance equation between internal heat production and the body's thermal losses. After some formal rearranging, this follows the form

$$0.601(q_M - q_W) - q_M(0.147 - 1.7 \times 10^{-5} p_i - 0.0014 t_i) \quad (1)$$
$$(+ 6.937 + 3.05 \times 10^{-3} p_i = 3.96 \times 10^{-8} \times f_{cl}[(t_{cl} + 273)^4 - (t_r + 273)^4] + f_{cl} \times h_c(t_{cl} - t_i)$$

and in the equation of the surface temperature of clothing, which could also be formally rearranged to

$$t_{cl}^{comf} = 35.7 - 0.0275(q_M - q_W) - R_{cl}[0.601(q_M - q_W) \quad (2)$$
$$- q_M(0.147 - 1.7 \times 10^{-5} p_i - 0.0014 t_i) + 3.05 \times 10^{-3} p_i + 6.937]$$

where

- t_i is the indoor-air temperature (°C),
- t_r is the mean radiant temperature (°C),
- p_i is the partial vapor pressure (Pa),
- f_{cl} is the ratio between the surface area of clothed and nude occupant,
- R_{cl} is the thermal resistance of clothing (m^2 K W^{-1}),
- h_c is the convective heat transfer coefficient (W m^{-2} K^{-1}),
- q_M is the metabolic rate (W m^{-2}),
- q_W is the heat rate from external work (W m^{-2}).

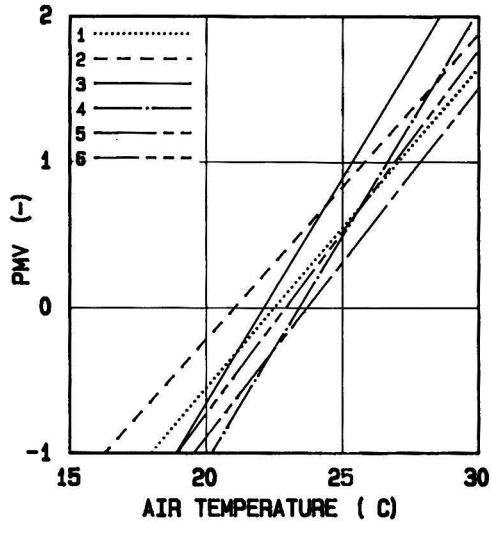
For dwellings and office buildings the assumption $q_W = 0$ W m^{-2} (no external work is present) could be made.

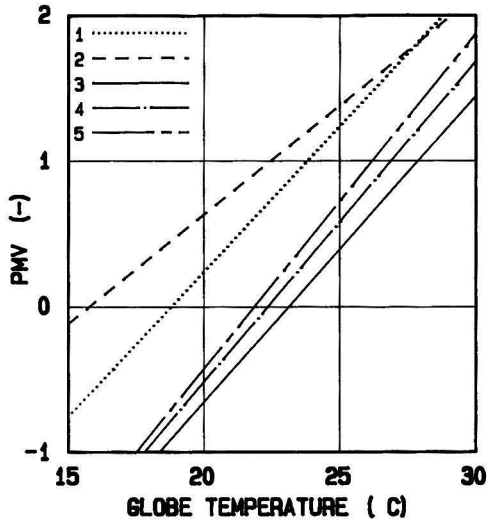
The first term of the right side of the Eq. 1 could be linearized

$$3.96 \times 10^{-8} f_{cl}[(t_{cl} + 273)^4 - (t_r + 273)^4] = h_r f_{cl}(t_{cl} - t_r) \quad (3)$$

where h_r represents the radiant heat transfer coefficient (W m^{-2} K^{-1}). Consider the partial vapor pressure to be $p_i = 1402$ Pa (e.g., $t_i = 20$°C and relative humidity rh = 60%) then Eq. 1 could be simplified into

$$q_M(0.478 + 0.0014 t_i) + 11.213 = \quad (4)$$
$$f_{cl}[(h_c + h_r)t_{cl} - (h_c t_i + h_r t_r)].$$





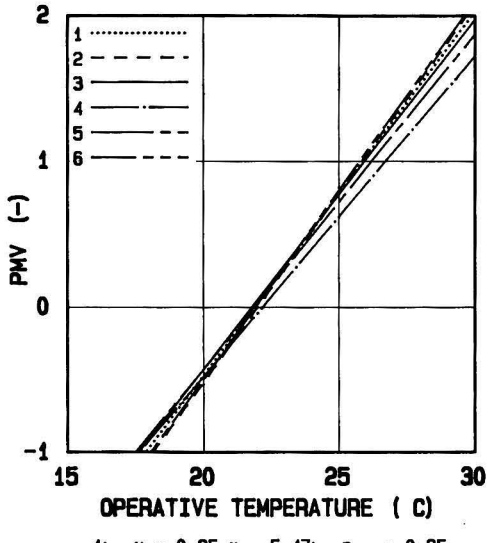


Fig. 6. Correlation between measured PMV-index and air, globe, and operative temperature, respectively (thermal resistance of clothing R_{cl} = 0.124 m² K W⁻¹, standing subject - level 1.1 m over floor, activity q_M = 70 W m⁻²).

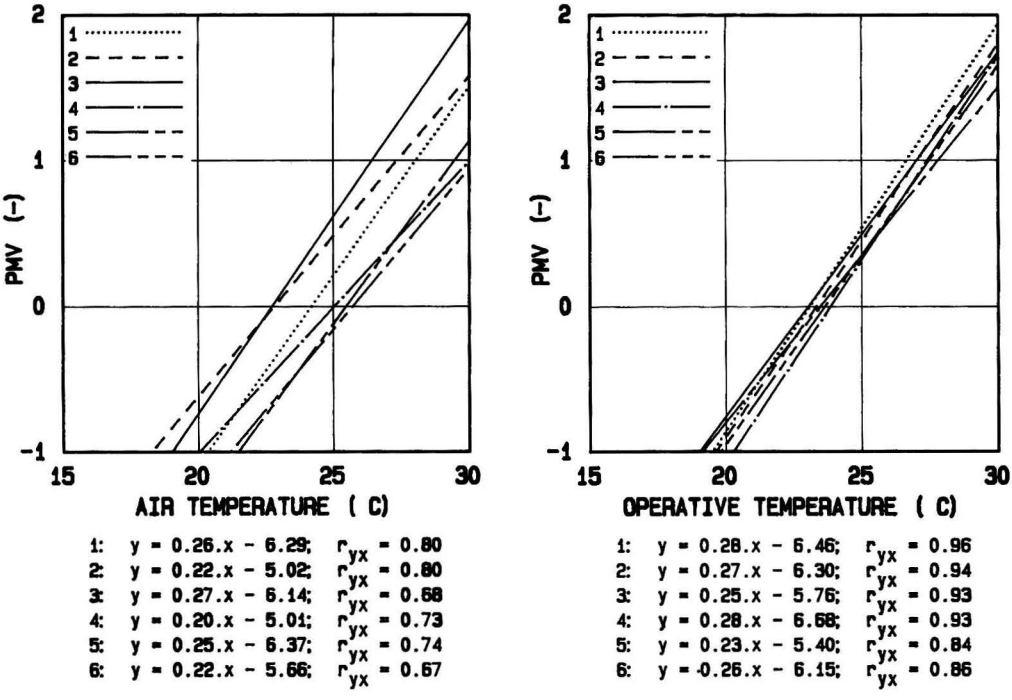


Fig. 7. Correlation between measured PMV-index and air, globe, and operative temperature, respectively (thermal resistance of clothing R_{cl} = 0.124 m² K W⁻¹, sedentary subject - level 0.6 m over floor, activity q_M = 60 W m²).

The operative temperature t_o is defined with the formula

$$t_o = (h_c t_i + h_r t_r)/(h_c + h_r) \quad (5)$$

and then

$$q_M(0.478 + 0.0014\, t_i) + 11.213 = f_{cl}(h_c + h_r)\,(t_{cl} - t_o). \quad (6)$$

In dwellings and office buildings the indoor-air temperature should always be between t_i = 18 °C and t_i = 26 °C. With an accepted loss of accuracy of ±1.1% instead of the actual value of t_i in Eq. 5 the value t_i = 22°C could be inserted and then

$$0.509q_M + 11.213 = f_{cl}(h_c + h_r)\,(t_{cl} - t_o). \quad (7)$$

It is possible to rearrange Eq. 2 in the same way

$$t_{cl}^{comf} = 35.7 - 0.0275q_M - R_{cl}(0.509q_M + 11.213). \quad (8)$$

From Eqs. 6 and 7 the operative temperature for the state of thermal comfort could be evaluated with

$$t_o^{comf} = t_{cl}^{comf} - (0.509q_M + 11.213)/[(h_c + h_r)\, f_{cl}] \quad (9)$$

whereby

$$f_{cl} = 1.00 + 1.290\, R_{cl} \text{ for } R_{cl} \le 0.078 \text{ m}^2 \text{ K W}^{-1} \quad (10)$$
$$f_{cl} = 1.05 + 0.645\, R_{cl} \text{ for } R_{cl} > 0.078 \text{ m}^2 \text{ K W}^{-1}$$

and the values of R_{cl} and q_M should be taken for example from Fanger (1970) or ISO 7730, ASHRAE standard 55-1981, respectively. Equation 9 is an easy-to-use comfort criterion suitable for practical civil engineering.

A more general definition for limit values of a specified comfort (or discomfort) interval could be derived with the aid of Fanger's PMV-index.

$$t_o^{limit} = t_{cl}^{disc} + [PMV / [0.303 \exp(-0.036 q_M) + 0.0275] - 0.509\, q_M - 11.213] / [(h_c + h_r) f_{cl}] \quad (11)$$

$\exp(a) = e^a$

and

$$t_{cl}^{disc} = 35.7 - 0.0275\, q_M - R_{cl} f_{cl} (h_c + h_r)(t_{cl}^{disc} - t_o^{limit}) \quad (12)$$

Equations 11 and 12 are a little cumbersome to use because of the necessary double iteration.

The convective heat transfer coefficient should be determined from

$$h_c = 2.38(t_{cl} - t_i)^{0.25} \text{ for } 2.38(t_{cl} - t_i)^{0.25} \geq 12.1\, v_i^{0.5}$$
$$h_c = 12.1\, v_i^{0.5} \text{ for } 2.38(t_{cl} - t_i)^{0.25} < 12.1\, v_i^{0.5} \quad (13)$$

where v_i is indoor air velocity (m s^{-1}).

With the aid of the proposed simplification the complicated Fanger formula has been transformed into more operative forms with only a negligible loss of accuracy. Equations 8, 9, 10, and 13 are easy-to-use in practical civil engineering. However, for determining the operative temperature one needs, as shown in Eq. 5, to evaluate the mean radiant temperature t_r

$$t_r = \sum_{j=1}^{j=n} t_{is,j} F_j \quad (14)$$

where $t_{is,j}$ - internal surface temperature of the j-th isothermal construction (°C), F_j - angle factor between the occupant and the j-th isothermal construction - should be taken from Fanger (1970) or better from Horikoshi and Kobayashi (1978a, 1978b, 1982).

Now derive the value of the radiant heat transfer coefficient. Fanger (1970) determined

$$3.96 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4} = s\, e_b e_s f_{eff} \quad (15)$$

whereby with the aforementioned proposed simplification

$$h_r = s\, e_b e_s f_{eff} k \quad (16)$$

In Eqs. 15 and 16

- s - Stefan-Boltzmann's constant, $s = 5.67 \times 10^{-8}$ W m^{-2} K^{-4},
- e_b - emissivity of the human body, $e_b = 0.97$,
- e_s - emissivity of the surrounding surfaces, $e_s = 1$ (Fanger assumed structural materials to be gray bodies with properties very close to that of the black body),
- f_{eff} - effective ratio between the irradiated and whole surface area of the human body, $f_{eff} = 0.72$,
- k - temperature coefficient (K^3) to be determined from $k = [(t_{cl} + 273)^4 - (t_r + 273)^4] / (t_{cl} - t_r)$.

In a mathematical model it is not possible to assume the value of the mean emissivity to be $e_s = 1$, but to evaluate it for each position in the environment

$$e_s = \sum_{j=1}^{j=n} e_{is,j} F_j \quad (17)$$

where $e_{is,j}$ - emissivity of the j-th isothermal inter nal surface, F_j - angle factor between the j-th isothermal internal surface and the occupant.

Due to the great popularity of tables among designers, comfort and limit values were calculated for operative temperature t_o for an optimal domain. Some of them, for possible combinations of thermal resistance of clothing and metabolic rate in dwellings and office buildings, are shown in Tables 1 through 4.

CONCLUSIONS

On the basis of inquiry research it has been shown that the mean indoor-air temperature during the heating period exceeds the prescribed or assumed value in some of the European building codes (20°C). The increase is significant. The older the building, the higher the mean indoor-air temperature and the mean subjective thermal sensation along with a simultaneous lowering of the mean thermal resistance of clothing. Technical measures such as low U-values and devices for spot regulation are not sufficient enough without economic stimulation to guarantee adequate energy savings.

For practical civil engineering operative temperature is a very suitable integrative checking parameter when designing building structures and technical equipment for occupant use. A simplification of Fanger's comfort formula leads to very operative forms which are easy-to-use during the designing.

Table 1 + 2. Table of comfort and limit values of the operative temperature for an optimal domain in dwellings and office buildings.

PMV = -0.500; v_i = 0.10 m s^{-1}; PPD = 10 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	28.4	27.2	25.3	24.0	22.7
58	26.9	25.5	23.2	21.6	20.1
70	25.3	23.6	20.9	19.0	17.2
93	22.1	19.9	16.3	14.1	11.9
117	18.9	16.0	11.8	9.1	6.4

PMV = 0.000; v_i = 0.10 m s^{-1}; PPD = 0 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	29.0	28.0	26.4	25.2	24.2
58	27.8	26.6	24.7	23.4	22.2
70	26.5	25.0	22.8	21.4	20.0
93	23.8	22.0	19.3	17.5	15.7
117	20.9	18.8	15.5	13.3	11.1

PMV = +0.500; v_i = 0.10 m s^{-1}; PPD = 10 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	29.7	28.9	27.6	26.7	25.8
58	28.7	27.8	26.3	25.3	24.3
70	27.7	26.7	25.0	23.9	22.7
93	25.7	24.4	22.3	20.9	19.5
117	23.3	21.7	19.2	17.5	15.8

PMV = -0.500; v_i = 0.20 m s^{-1}; PPD = 10 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	28.7	27.5	25.7	24.5	23.2
58	27.4	26.0	23.8	22.4	20.9
70	25.9	24.2	21.7	20.0	18.3
93	23.0	20.9	17.7	15.5	13.3
117	20.1	17.6	13.6	10.9	8.2

PMV = 0.000; v_i = 0.20 m s^{-1}; PPD = 0 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	29.5	28.5	26.9	25.8	24.8
58	28.4	27.2	25.4	24.1	22.9
70	27.1	25.8	23.7	22.3	20.8
93	24.8	23.1	20.4	18.6	16.8
117	22.2	20.2	17.0	14.8	12.6

PMV = +0.500; v_i = 0.20 m s^{-1}; PPD = 10 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	30.2	29.4	28.1	27.2	26.3
58	29.4	28.4	26.9	25.9	24.9
70	28.4	27.3	25.7	24.5	23.4
93	26.5	25.2	23.2	21.8	20.4
117	24.4	22.8	20.3	18.6	16.9

Table 3 + 4. Table of comfort and limit values of the operative temperature for an optimal domain in dwellings and office buildings.

PMV = -0.500; v_i = 0.40 m s^{-1}; PPD = 10 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	29.4	28.2	26.4	25.2	23.9
58	28.2	26.8	24.7	23.2	21.7
70	26.9	25.2	22.7	21.0	19.3
93	24.3	22.2	19.0	16.8	14.6
117	21.7	19.2	15.3	12.6	9.9

PMV = 0.000; v_i = 0.40 m s^{-1}; PPD = 0 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	30.1	29.1	27.5	26.4	25.4
58	29.1	27.9	26.1	24.8	23.6
70	28.0	26.6	24.5	23.1	21.7
93	25.8	24.1	21.5	19.7	17.9
117	23.6	21.5	18.3	16.1	13.9

PMV = +0.500; v_i = 0.40 m s^{-1}; PPD = 10 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	30.8	29.9	28.6	27.7	26.8
58	30.0	29.0	27.5	26.5	25.5
70	29.1	28.0	26.3	25.2	24.0
93	27.4	26.0	24.0	22.6	21.2
117	25.4	23.8	21.3	19.6	17.9

PMV = -0.500; v_i = 0.30 m s^{-1}; PPD = 10 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	29.1	28.0	26.1	24.9	23.7
58	27.9	26.5	24.3	22.9	21.4
70	26.5	24.8	22.3	20.6	18.9
93	23.8	21.7	18.5	16.3	14.1
117	21.1	18.6	14.6	11.9	9.2

PMV = 0.000; v_i = 0.30 m s^{-1}; PPD = 0 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	29.8	28.8	27.3	26.2	25.1
58	28.8	27.6	25.8	24.6	23.3
70	27.6	26.3	24.2	22.8	21.3
93	25.4	23.7	21.1	19.3	17.5
117	23.0	21.0	17.7	15.6	13.4

PMV = +0.500; v_i = 0.30 m s^{-1}; PPD = 10 %

q_M [W m^{-2}]	R_{cl} [m^2 K W^{-1}]				
	0.047	0.078	0.124	0.155	0.186
47	30.5	29.7	28.4	27.5	26.6
58	29.7	28.8	27.3	26.3	25.3
70	28.8	27.7	26.1	24.9	23.8
93	27.0	25.7	23.6	22.2	20.9
117	25.0	23.4	20.9	19.2	17.5

For practitioners, tables of comfort and limit values of the operative temperature t_o for an optimal domain to be defined with a maximum of 10% of thermally dissatisfied occupants have been calculated. The calculations have been done for possible combinations and activity of occupants in dwellings and office buildings. This method integrates the simplicity of temperature criterion and the complexity of Fanger's thermal comfort model.

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MEASUREMENT OF AMBIENT AIR LEAD CONCENTRATIONS IN THE CITY OF JEDDAH, SAUDI ARABIA

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Lead concentrations were determined in six different locations in the Jeddah urban area by atomic absorption spectrometry. Correlations between the air-Pb data and traffic density were investigated. The lead concentration values obtained for the ambient air in Jeddah City ranged from 0.19 μg/m³ to 1.27 μg/m³. Comparison with ambient air quality standards from other countries indicates that certain areas in this city are approaching these guideline values.

INTRODUCTION

Measurement of ambient lead is of great importance in the study of its health effects on man. Lead in the atmosphere represents a significant source of human exposure both directly by inhalation and indirectly through the deposition of air particulates on water, soil, and vegetation. During inhalation a significant part (30-60%) of the airborne lead is deposited in the respiratory region; the remainder is re-exhaled. Lead aerosols less than 1 μm in diameter are expected to deposit almost exclusively in the alveolar region where most of the lead is taken up by the blood (Facchetti and Geiss 1982; Chamberlain 1983). Lead transported within the system can be taken up by the peripheral compartments and returned to the environment, the dominant removal route being kidney excretion via urine (Colombo 1985). In a previous study by the authors (Ahmed et al. 1988), a strong correlation between lead concentrations in air and in biological tissues such as hair was found. Levels in hair were on the high side of the internationally accepted "normal" concentrations of 10-30 mg/kg, indicating the importance of biological monitoring for environmental lead pollution.

One of the important sources of atmospheric lead in urban areas is the emission from motor vehicles using leaded gasoline. According to an estimate by Boeckx (1986), about 86% of all lead emitted into the atmosphere comes from automobile exhaust. In a study by Khan (1981), a good correlation was found between air lead concentrations and traffic volume. The data are, however, dependent on the prevailing meteorological conditions and driving mode. Nasralla (1984) showed that the lead concentration in the dust of Jeddah city is directly related to the traffic density.

Measurements of atmospheric lead concentration in Riyadh (Shobokshy 1984) and in Jeddah (MEPA 1985) also indicate similar results. In a study conducted in Ontario, Canada (Heidorn and Rohac 1981), it was found that there has been a steady decrease in the annual average lead levels from 1972 to 1979, parallel to a reduction of lead content of the gasoline since 1972, and reduction of lead emissions by 68% compared to 1970 emissions. Brown (1986) showed that the lead content of the dust decreased exponentially with distance of the sampling site from the street, indicating the direct influence of traffic on lead concentrations. In the United Kingdom (UK De-

partment of Environment 1987) and West Germany (Harrison and Laxen 1981), the maximum permitted lead content of gasoline is 0.15 g/L. In the United States, along with the use of unleaded gasoline, the maximum allowable limit for normal gasoline was set at 0.10 g/L (U.S. EPA 1985).

The number of automobiles in Saudi Arabia has increased substantially over the years, from 243 000 cars in 1973 to 3.8 million in 1983 (KSA 1983) and is estimated to be over 5 million at present. In view of this considerable increase in automobiles, all using leaded gasoline, it was thought necessary to check the present air-lead concentrations in Jeddah which is one of the most densely populated cities in Saudi Arabia, and compare these with the air quality criteria for lead in air. The European Economic Commission (EEC 1977) fixed a limit for lead in air of 2.0 $\mu g/m^3$, and in the United States the maximum limit was set at 1.5 $\mu m/m^3$ (U.S. EPA 1981). The air quality standard developed by the U.S. Environmental Protection Agency was based on the assumption that at zero lead level, a child's blood lead level would average 12 µg/dL due to all sources of lead exposure (from soil, dust, food, and water), except air. They then determined that an air lead level of 1.5 $\mu g/m^3$ would result in a geometric mean blood lead of 15 µg/dL, which is consistent with the blood lead guideline of 25 µg/dL (CDC 1985).

EXPERIMENTAL SECTION

Site selection

Six areas in Jeddah city representing different traffic densities were chosen for this study. These locations were: Al-Mutanabbi School in north Jeddah near the Red Sea coast; two schools representing residential areas in the Al-Hamra and Al-Bawadi districts; the Al-Thaghr School in an open area near one of the arterial roads with heavy traffic (Makkah Road); Al-Amoudi Center (busy commercial area); and the downtown (King Abdulaziz Street with high densities of tall buildings).

In order to study the correlation with traffic density, the number of automobiles per 30 minute intervals were counted over a period of several days in each area. The count was taken at different 30 minute intervals several times during the air sampling period, and an average of these counts was taken.

Sampling

Samples were collected from each area by a Hi-Volume Sampler (Model 2000, General Metal Works) using fiberglass filters. Air was drawn through the filter for 24 hours per sample over a period of 2-3 weeks during 1987. Typical total air volumes for each sample were in the range of 2345-3230 m^3.

Analytical techniques

Small portions of the filter paper were weighed, digested in aqua regia, and the resulting solution was dried at 80°C in an oven. The dried residue was dissolved in 1% HNO_3. The solution was centrifuged and the clear supernatant was assayed for lead by a Perkin Elmer Atomic Absorption Spectrophotometer (Model 603) using the flame method. The calibration curve was prepared by serial dilution of the stock lead standard solution obtained from Fischer Scientific Co., U.S.A. Blank fiberglass solutions prepared from the filters in the same way as the actual samples were run to correct for the background lead in the fiberglass.

Table 1. Traffic flow rate and air-Pb concentration.

Locality	No. of Automobiles per 30 minute	Air-Pb Concentration ($\mu g/m^3$), Mean ±S D
Al Mutanabbi School	14	0.19±0.03
Al Hamra District	25	0.53±0.14
Al Bawadi District	33	0.63±0.09
Al Thaghr School	666	0.65±0.02
King Abdulaziz Street	766	0.91±0.22
Al Amoudi Center	1090	1.27±0.23

RESULTS AND DISCUSSION

Lead concentrations

Table 1 shows the average air lead concentrations in the six different areas of Jeddah city along with the measured traffic flow rate. The mean air-lead concentrations from triplicate measurements range from 0.53 $\mu g/m^3$ to 1.27 $\mu g/m^3$. These values can be compared with the data from other industrialized nations. A study in the United Kingdom (DHSS 1980) showed that the overall annual concentration of lead in air was less than 1 $\mu g/m^3$. In West Germany the concentration near urban schools in the industrial city of Duisburg, where there is a lead smelter, was found to be 1.6 $\mu g/m^3$ compared with levels of 0.35 $\mu g/m^3$ in the more commercial city of Dusseldorf (Brockhaus et al. 1978). Thus the levels of lead in the Jeddah air are similar to those of industrialized countries, and are approaching the European Economic Commission and United States upper limits. However, the industrial activities in Jeddah are still much less than those in more developed countries, a fact which points to automobile exhausts as the major contributor to air lead in this city.

Analysis of variance

The Analysis of Variance test conducted on the air-lead concentration data for the six regions is shown in Table 2. The calculated F-value of 12.01 when compared with the tabulated value of 4.02 for (v_1 = 5, v_2 = 12) degrees of freedom at 5% level of significance indicates that the differences between sample means of different localities are genuine and not due to any chance or random factor.

Correlation with traffic density

That the mean air-lead concentrations in the six localities are inherently different can now be seen in light of the traffic flow rate in these areas. The average number of automobiles per several 30 minute intervals over a period of several days are shown in Table 1 along with the mean air-lead concentrations. The data in Table 1 indicate a positive correlation between the number of automobiles and air-lead concentrations. Figure 1 shows the linear regression for the data with the correlation coefficient of 0.87.

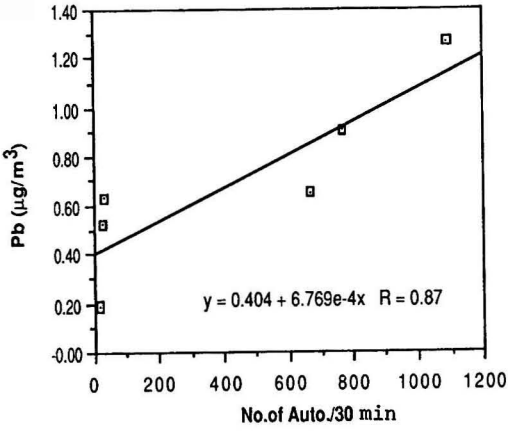

Fig. 1. Linear regression between air-Pb concentration and traffic flow rate.

Table 1 shows that the Al-Mutanabbi School area situated near the Red Sea coast in wide open space has the lowest ambient air-lead concentration. This could be due to the effective dispersion of the pollutants as a result of a stronger sea-land breeze and lower traffic density compared to other areas. This is followed by the two residential districts of Al-Hamra and Al-Bawadi where traffic flow rate is moderate. The next higher concentration was obtained near the Al-Thaghr School, situated beside a heavy traffic artery. This is followed by King Abdulaziz Street in the middle of the downtown area with congested high-rise buildings and heavy traffic during the daytime. The heaviest traffic density is seen at Al-Amudi Center area, one of the busiest commercial districts

Table 2. ANOVA table for interlocality comparison.

Source of Variation	Sum Square	D.F.	Mean Sum Square	F
Between	1.980134	5	0.3960267	12.01
Within	0.395665	12	0.0329722	

situated on a very heavily trafficked road leading to and from downtown. It is also situated at a major traffic crossroad where the vehicle flow is often congested.

Relation to hair-lead studies

The present data for air-lead concentrations at Al-Mutanabbi School and Al-Thagr School areas agree with the hair-lead concentrations in the children of the same two schools measured by the authors in which four schools in Jeddah city including the two mentioned above were chosen for hair-lead measurements (Ahmed et al. 1988). It was found that Al-Mutanabbi School children had the lowest mean hair-lead concentration (16.8 ± 2.8 mg/kg) followed by Al-Thaghr School (23.0 ± 2.8 mg/kg). The other two areas showed hair-lead concentrations of 17.9 ± 2.3 mg/kg and 31.8 ± 3.9 mg/kg.

Comparison with other studies

It is interesting to compare the results of the present study with the findings of the Meteorology and Environmental Protection Administration (MEPA) of Saudi Arabia which conducted a similar study in Jeddah in 1985 (MEPA 1985). The MEPA study in two areas of Jeddah city with traffic flow rates of 432 cars/hour and 3611 cars/hour gave the air-lead concentrations as 0.70 $\mu g/m^3$ and 2.4 $\mu g/m^3$, respectively, again showing a direct correlation between traffic density and ambient airborne lead. In a study of lead concentration in the dust of Jeddah city, Nasralla (1984) showed that proximity to traffic plays a direct role in the increased lead content of streetside dusts. The average dust-lead concentration was found to be 745 μg/g, with the highest value of 1750 μg/g which is considerably higher than that found in many large cities in the developed countries, e.g. 1001 μg/g was reported for street dust of Birmingham City, England (Day et al. 1975). Since settling of airborne lead is the major source of dust lead, it is not surprising that Jeddah dust has a correspondingly high lead concentration.

From the above discussion, it may be concluded that lead concentrations in Jeddah ambient air, particularly in heavy traffic areas, are fast approaching the maximum safe limit set by international standards. This is further evidenced from the available data on lead concentrations in the dust and in the hair of the children in Jeddah. Since automobile exhaust from the burning of leaded gasoline has been identified as the major source of urban lead pollution, it is imperative that the lead content of Saudi Arabia's gasoline be further reduced, with the objective of completely eliminating it as soon as practicable according to a well-coordinated program between the industry and the government.

Acknowledgment — The authors would like to thank the Chairman of the Nuclear Engineering Department and the Chairman of the Civil Engineering Department, King Abdulaziz University, for providing the facilities for the work. Thanks are due to Mr. R. Rajput for technical assistance.

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BOOK REVIEWS

Planning for Changing Energy Conditions: Energy Policy Studies Vol. 4, edited by John Byrne and Daniel Rich. Transaction Books, New Brunswick, NY. (US $16.95, paper)

This book's title led me to expect a discourse on how to plan for changing energy conditions of the future. Instead, I found a mixture of expositions that describe the fairways and sandtraps of previous events. Many of the authors are respectable experts in their fields, but their "energy policy studies" seem more like relics than revelations.

The book contains writings on a small list of energy planning topics. There's a chapter on electric power planning in developing countries, two about coal consumption and land use, one concerning oil prices and urban lifestyle, and three others on energy planning from general perspectives. One chapter hangs alone. It's a shrunken, tortured version of the Maxey Flats fiasco: the nuclear waste disposal site in Kentucky.

Each chapter must stand (or hang) on its own merit, since the book is a showcase of expert opinion rather than an integrated treatise on energy planning. The showcase approach is common among publishers who issue "studies". Many such books are pointless potpourri. Some have great utility. This one falls somewhere in between.

Edward Cassedy and Peter Meier provide an informative analysis of electric power planning in the Third World. It reveals the struggle between planning policies for the common good and the politics of utility enterprises. In another chapter, Richard Gordon argues against a national policy of public land ownership. He claims that coal mining on leased public lands has been grossly mismanaged, disserving both environmental and economic interests. Privatization is the only way to get coal out of the ground efficiently, he says, and the "arrogated" liberals will just have to lump it.

William Chandler's chapter on planning for more efficient energy usage is well composed. Another chapter by Barry Cullingworth and William Sparling reviews one city's (Portland, OR) attempts to assemble a community energy plan. It shows how local issues and changing public attitudes influence planning efforts at a community level. The concluding chapter by Britton Harris is a pep talk about keeping an eye on the future, which seems like an important thing for planners to do.

Lessons from the past are the most unifying theme of this book. Many of these energy planners seem to face backward as they row forward and curse the politicians along the way. Where waste management politics is concerned, Kristin Shrader-Frechette uses the Maxey Flats event as a target for her self-righteous indignation. Even a referee of one of her own publications gets slammed in her pedantic diatribe.

Shrader-Frechette's intention is to dig up Maxey Flats one more time and hang it out for all to scorn. She sums up her planning philosophy with the worn-out quote from Santayana: "Those who forget history are condemned to repeat it." Pogo's "We have met the enemy and he is us" might have been more appropriate.

Readers of Environment International will enjoy her spicy chapter, nevertheless. Other chapters will have limited appeal to this readership, although there are rewards for those who appreciate case histories. Perhaps the most obvious and unintended message of this book concerns dwelling on the past. How much penetrating hindsight truly benefits our "planning for changing energy conditions" of the future? Retrograde criticism is only a rear view mirror, and its reflection can be distracting. This book caused me to wonder if planners are focused well enough on the road ahead, and if trial and error is our only means of navigation.

Richard Emery
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Radon and its Decay Products in Indoor Air, edited by William W. Nazaroff and Anthony V. Nero, Jr. John Wiley & Sons, Publishers, Inc., New York; (US $75.00)

Of the many books that have been published in the last few years in response to the "serious national health problem" associated with indoor radon, editors Nazaroff and Nero have put together one of the better ones. Each chapter is designed to be a review of the state of knowledge on a given topic and is well

referenced to support the discussions presented. It is comprehensive in its coverage of the subject matter. Part One: Sources and Transport Processes (Chapters 2 to 4); Part Two: Characteristics and Behavior of Radon (Chapters 5 to 6); Part Three: The Basis for Health Concerns (Chapters 7 to 9); Part Four: Controlling Indoor Exposures (Chapters 10 to 12). Chapter 1, by Nero, is an overview of the subject (about 10% of the total text); it provides the reader with a good understanding of the topics and a good lead into details presented in the various review chapters. The authors successfully met the editors' goal to "...provide insightful analysis of important aspects of the indoor radon problem....".

All authors put forth a commendable effort to produce an authoritative and scholarly review, and these efforts have culminated in a book that can serve as an excellent shelf reference for those interested in being aware of what is known about radon in the context of an environmental problem. The level of mathematics used is no more complex than that necessary to describe rate equations for the formation of radon decay products. Of the twelve senior authors of chapters, the editors contributed two chapters each, other U.S. scientists wrote two chapters, and six scientists from other countries contributed the remaining six chapters. Thus, the book has an international flavor.

Although not a serious detraction to the overall value of the book, I find somewhat naive the editors' views that "...indoor radon is exemplary of the broader issue of indoor air quality", that radon "...represents a relatively simple carcinogenic agent when compared, for example, with tobacco smoke", and that "...our understanding of carcinogenesis may be advanced by focusing efforts on radon as a model agent". While research using radon as a tool may serve as a non-invasive agent in stressing systems for biological information, it is unlikely to provide unique or substantive information on overall indoor air quality problems. Neither is it a simple carcinogenic agent nor is radon research likely to advance our understanding of the etiology of cancer. Research addressing radon should focus on the issues at hand, namely, on resolving public anxieties created by repeated media references to radon as a "deadly gas". In this context, I hope that indoor radon will not be "exemplary" of issues surrounding overall indoor air quality.

Future findings from research may result in substantive changes in radon risk assessments and control policies; however, its treatment of fundamentals should keep it current and useful for years to come. It, along with such publications as those of the National Council on Radiation Protection and Measurements on Radon (Reports No. 77 and No. 78) and the National Academy of Sciences/National Research Council BEIR IV Report are likely to be among the references on the subject most often cited.

William A. Mills
Washington, D.C.

Radon and the Environment, edited by William J. Makofske and Michael R. Edelstein. Noyes Publications, Park Ridge, NJ, 1988. (465 pp., US $39.00)

The subject book is the published proceedings of a conference sponsored by the Institute of Environmental Studies at Ramapo College of New Jersey on May 8, 9, and 10, 1986. According to the editors, Makofske (a psychologist) and Edelstein (a physicist), the objective of the conference was to view the radon issue in terms of an interdisciplinary analysis and "... to combine the objective communication among professionals and communication to the public". The conference "... was designed to bring together many of the key contributors to our current knowledge of radon in a forum which would clarify the policy issues". The reader will find the policy issues identified perhaps, but far from being clarified.

The editors have done a commendable job in presenting a mass of material in a logical sequence. Section 1 is an overview of the radon issue written by the editors, which with introduction and summary statements for other sections attempts to provide the "reader less familiar with radon ... a pathway into the specific papers". Sections 2 to 5 address scientific topics on geographic distribution, transmission and mitigation, testing and measurement, and health. While the information in these sections are of some interest, better information can be found in a number of more current publications such as the (U.S.) National Academy of Sciences/National Research Council report BEIR IV and the National Council on Radiation Protection and Measurements' Report No. 97 on Measurement of Radon and Radon Daughters in Air, and various publications of the U.S. Environmental Protection Agency. Sections 6 to 8 address perceptions of risk and psychological impacts, socioeconomic impacts (including legal implications), and the role of government in responding to the radon issue. Of special note in this last section is the presentation by Senator Lautenberg of New Jersey, who outlines his program for Federal government involvement in resolving radon issues; a program which he

subsequently puts into place through legislation. He suggests that some may believe that "... the 'R' in Frank R. Lautenberg stands for radon". (This reviewer would not disagree.) Highlights of the discussion between conference participants follows each section and presents some of the more interesting reading.

In the section on perception of risk and psychological impacts of radon exposure, the reader will find concern over the public apathy displayed by the majority; an apathy which still exists in spite of the efforts of government and media encouraging the public to be more proactive, especially in home radon testing. Panic over radon exposures and over prospects of an increased risk of lung cancer was not found in surveys conducted in New Jersey. The authority reporting on this study states that public apathy exists "... not because the public is uninformed about radon...but rather because many of the things they believe about radon cause them to underestimate the risk." Perhaps the public is wiser than many decision makers are willing to accept. This raises the intriguing question as to whether the public better understands the probability of actual risk than those in government and the media who are pushing the indoor radon issue as a "serious national health problem". This is one of the many policy issues not clarified for the reader of these proceedings.

William Mills
Washington, D.C.

Environmental Permits: A Time-Saving Guide, by Donna C. Rona. Van Nostrand Reinhold Company, NY, 1988. (433 pages)

For some time, the diversity of environmental permitting requirements affecting development projects has evaded categorical treatment as a literary or scientific subject. From a literary perspective the subject could be perceived as too broad in scope or, alternatively, trite in view of some of the more fundamental environmental issues facing this generation. From a scientific point-of-view the amorphous nature of the subject and the subjectivity of the judgments defies Hegelian logic. In her recent book, Rona brings together some of the disparate topics affecting the permitting process and establishes a set of functional categories. She also promotes a three-fold approach to the implementation of a permitting program. The functional categories can be defined by the range of topics dealt with in the book. This includes permit application development, processing, and negotiating, public review procedures, and environmental litigation. Her treatment of these topics is broad; she does not attempt to give a comprehensive listing of all types of environmental permits in the various states. What is accomplished is a broad brush image of the general categories of permitting programs applicable to various types of development projects. She gives a general idea of the key issues involved in coordination and communications, and supplements her discussions with many specific examples from various states' permitting programs. She includes eleven separate appendices and hundreds of exhibits. By using this overview approach she promotes a general framework suitable for a textbook. The book would be an excellent choice for college level classes in engineering and environmental science.

Her three-fold approach includes practical suggestions for making permits accurate and defensible. First, she advocates a cooperative attitude by developers and their consultants with the regulatory agencies. She deals quite frankly with the relative inexperience of many agency officials, given public sector pay scales and the high turnover rates in environmental management agencies. She notes, almost delicately, that the lack of experience of some of these officials may contribute to subjective, value-laden decisions that stem from their own personal agendas, rather than a genuine balancing of the overall costs and benefits of the project. This, she argues, may lead to project delays and rising costs. To counter this undesirable outcome, she suggests a cooperative attitude be taken by project engineers and developers.

Second, she advocates centralization of permit application administrative management (by the permit applicant). She notes that the permanent record must be carefully maintained to document design and procedural decisions made early in the application process.

Finally, she urges readers to use a well-designed quality assurance/quality control process in the data acquisition and permit form development phases. This, she argues, will provide the necessary documentation if a disagreement about a permit requirement arises between an agency official and a permit applicant.

One chapter of the book is devoted to "environmental reports". Rona intended this discussion to be generic to any technical background document supporting a design decision. However, she focuses primarily on the decision analysis of an environmental impact statement (EIS) rather than on more general technical or resource documents that must accompany certain permit applications. She does acknowledge

that an EIS cannot be depicted as an "environmental permit". Nonetheless, she focuses almost a whole chapter on a process that might be more appropriately labeled a review rather than a permit process. She also devotes three appendices to the legal and regulatory requirements for compliance with the National Environmental Policy Act (NEPA). Although this is useful information for a lay audience, or even for an audience of young environmental professionals, a more useful approach for professionals working in the environmental management business in the late-1980's might have been to detail the regulatory objectives of the permit programs under the Resource Conservation and Recovery Act (RCRA), the Clean Water Act (CWA), the Federal Safe Drinking Water Act (FSDWA), and the Clean Air Act (CAA).

The Part B Permit Application under RCRA for hazardous waste treatment, storage, and disposal facilities, the National Pollutant Discharge Elimination System (NPDES) permit process under the CWA for liquid effluent discharges to surface waters, the Underground Injection Control (UIC) permit program for controlled disposal of liquids in deep aquifers, and the Prevention of Significant Deterioration (PSD) permit program under the CAA are examples of national permit programs for which her three-fold approach would have direct applicability. Basic components of these programs, such as the delegation of authority for statement implementation, could have been described more completely in the Rona book. Furthermore the interface issues of the various programs may have helped to alert readers to the need for a general understanding of each of these major programs. For example, an engineer who works in RCRA Part B permitting should have a general understanding of the use of maximum contaminant levels (MCLs) for groundwater monitoring and corrective action programs (under 40 CFR 264) and how that relates to the National Interim Primary Drinking Water Regulations (under 40 CFR 141). Interface issues are of importance from both a project management perspective (in terms of scheduling and resource loading) and from a technical/legal perspective (in terms of providing justification why the applicant proposes a certain effluent limit or cleanup level). This book would have been even more valuable if some of these basic regulatory program interrelationships had been described.

Another perspective that would have strengthened the book is a discussion of the underlying principals of a trend in environmental permitting that might be called "cooperative management". An understanding of the practical implications of this approach that advocates mutual respect for all interested parties would have given greater depth to Rona's argument that cooperation is a critical element in advancing the objectives of both the applicant and the regulatory agency. Although the book is written from the point-of-view of the regulated community, the broad nature of the discussions make it a perfect primer for rookie regulators. With an explanation of these concepts, it would have provided an opportunity for attuning young, ambitious regulatory agency staff to the cost implications and technical feasibility of agency requests. The development of this perspective requires a basic understanding of both the engineering questions and the ethical bases for the regulated community. Too often the assumption that the profit motive drives all regulated community decisions colors the agency staffers' ability to maintain objectivity in the permitting process. Respect for the management constraints of the applicants by the regulators will greatly enhance understanding and cooperation from the developers.

Similarly, respect for the ideals of the regulators on the part of the developers will promote cooperation as well. The assumption that agency staff are "tree-huggers" reduces the opportunity for real communication between the parties. The fundamental concerns and objectives of regulatory agency staff and their institutions have a legitimacy that extends beyond the immediacy of any particular permit action. This legitimacy is based on the fact that these state and Federal agencies have been created and are perpetuated by public representatives. The basic need for environmental permits stems from the mismatch between free trade, (i.e., private sector profit motives) and the public good. A discussion of these issues would have strengthened the book, challenged the reader, and made the reader less likely to adopt the stereotypical characterizations of involved parties.

The issue of international environmental management and permitting is not dealt with at all in the book. International environmental business requirements pose a completely different set of legal, regulatory, and ethical questions. Rona was wise to limit her discussion to the permitting issues relevant to the United States. However, this issue should receive attention in the near future, given that environmental permitting programs are becoming more prevalent in other countries.

In summary, the book is a valuable addition to the literature of practical guides in the field of environmental management. It gives a general overview of the generic process and outlines some considerations

managers should make when developing and negotiating permit conditions. It does not, however, provide an in-depth analysis of the historical significance of the key national environmental permitting programs. Furthermore, it does not attempt to provide a literary or scientific basis for understanding the permit process. Knowledge of this history, philosophy, sociology, and economy of permit programs will also help to save time in this sometimes effective, sometimes tedious, environmental management process.

Jane Holderman
Issaquah, WA

Environmental Policies in East and West, edited by G. Enyedy, A. Gijswijt, & B. Rhode. Taylor Graham, London (401 pp., US $65.00).

This environmental policy analysis book was written by social scientists from 14 countries in Eastern and Western Europe under the auspices of the European Coordination Center for Research and Documentation in Social Sciences. The objective of the work is to facilitate a better understanding of environmental problems and problem-solving strategies being used in Europe. Authors involved are from Austria, Bulgaria, Czechoslovakia, Denmark, France, East Germany, West Germany, Great Britain, Hungary, Italy, Netherlands, Poland, Soviet Union, and Yugoslavia.

The book is organized into country-specific discussions of nearly uniform outlines. The standard contents include:

1. Background Information
   A. Physical characteristics of the country
   B. Historical review of environmental problems
   C. Environmental status indicators
   D. Legal system
   E. Historical successes and failures
2. Institutions
3. Decision-Making Processes
   A. Political
   B. Economic
   C. Public
   D. Monitoring
   E. Constraints and conflicts

Within the context of this general outline, the discussions range in presentation style from nearly conversational to quantitative, depending upon the central focus of the environmental policies being pursued in a particular country and the means by which the policies are being implemented. The main point made throughout the book is that even though the environmental problems in ecologically similar regions of Europe tend to be similar, the means by which they have historically been addressed has been very dependent upon whether the country has a market-driven economy or a centrally-planned economy. A second point is that European geography dictates that one country's environmental problem is likely to be several others' problem as well.

The book looks at Europe as a geographical system, subdivided into major drainage basins. The physical descriptions of these systems are couched in terms of energy budgets. This approach is taken on the basis that environmental problems often stem from the ways by which usable energy is created and used. The influence of the institutional and decision-making mechanisms employed to respond to environmental problems is the focus of this book.

The case studies presented will be of interest to a wide variety of readers because of their cognizance of the influence of physical, biological, and social sciences on the need for, development and outcomes of environmental policies. A physical geographer will perhaps be able to see the difficulties being both caused and solved through his discipline. Likewise, a political scientist may draw the same conclusions regarding his discipline. Regardless of one's final interpretation of the events portrayed in the book, it is an enjoyable and informative book to read. For those readers with specific interests, like environmental statutes in a particular country, references for more detailed study are given.

The basic outlines used for each country's discussion are similar. Therefore, an excellent opportunity for direct comparisons of viable alternative policies and implementation approaches exists. As might be expected, in the market-driven economies, the most efficient mechanism to effect change is through the legislative process. In contrast, in a planned economy country, the most effective means of bringing about change is through the planning process.

On this point, the authors note that in Western countries, "The idea of an agreed goal of society is not a governing idea". In contrast in socialist societies, "It is realistic to set harmony between nature, the environment and society as an objective". It is pointed out that neither approach automatically makes the desired change occur. In a market economy, one must seek to influence the means by which conflicting goals are resolved. In planned economies one seeks to have environmental objectives recognized for their importance and embodied in plans.

In reading the book one comes to realize that there are mechanisms being used in Eastern Europe that would be effective in the West and vice versa. After being made aware of the first localized effects of the agricultural revolution in Europe as contrasted to the global effects of the industrial revolution, one gets the feeling that people everywhere are beginning to realize that most fundamental environmental problems are international in scope. We are, therefore, beginning to look for successes, wherever in the world they may have occurred.

The book concludes with three chapters on collaborative arrangements that are being used to accelerate the use of this "internationalized" problem-solving approach. The first such arrangement involves the European socialist countries. The second addresses environmental protection in Western Europe and the third is the United Nations Economic Commission for Europe. These chapters enumerate the structures of these organizations, the issues they have addressed, and the means by which they strive to accomplish their objectives.

The realization that seems to be emerging from the continued operation of these arrangements is best summed up in the Hungarian chapter where it is stated, "The mutual interests are so clear...that crossing the borders made for ideological, political and security considerations seems to be necessary".

David A. Waite
Issaquah, WA

State of the World 1989, A Worldwatch Institute Report on Progress Toward a Sustainable Society. (1989), by Lester R. Brown and others. W.W. Norton & Company, New York. (xvi + 256 pp. paperback, US $9.95, ISBN 0-393-30567-8)

The sixth in an annual series from the Worldwatch Institute, this report focuses on global climate change and the interrelated problems of population growth, land degradation, and decreasing ability to feed the world's population. Global statistics and local anecdotal reports fill nine chapters including "Halting land degradation", "Reexamining the world's food prospect", "Abandoning homelands", "Protecting the ozone layer", "Rethinking transportation", and "Responding to AIDS".

The authors report that climate change has so much momentum now that it can only be slowed, not stopped. Future generations will have to cope with a warmer world. It hits the two key factors in global climate change: (1) it is not the small average change that is more important, but the extremes: droughts, heat waves, and devastating hurricanes, and (2) most at risk are the almost 4 billion people who live in the third world who lack the resources to protect themselves.

The book concludes with an action plan for global environmental problems while considering the difficult problems of social equity, national sovereignty, and individual rights. The plan proposes four action areas: (1) developing a climate-sensitive energy strategy, (2) expanding forest cover, (3) increasing efforts to meet food needs, and (4) braking the momentum of population growth.

These are all socio-environmental problems, and most of them are real and pressing on a global scale. The book tends to assume more certainty of the relationship between increased anthropogenic CO_2 emissions and climate change than many scientists are willing to concede. Moreover, while recognizing the widespread public rejection of nuclear power, the book minimizes its potential role in reducing global CO_2 emissions. On the other hand, it seems over-optimistic on the potential for new technologies, such as photovoltaics, to replace fossil fuels.

Despite these shortcomings, the book is highly recommended. It includes an extensive index and 48 pages of notes detailing the sources and calculation methods behind the statistics cited in the text. It is available in most major languages, including Arabic, Chinese, English, Italian, and Russian.

S.C. Morris
Upton, NY

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BOOKS RECEIVED

Compendium of Chemical Terminology. IUPAC Recommendations compiled by Victor Gold, Kurt L. Loening, Alan D. McNaught and Pamil Sehmi. Blackwell Scientific Publications, Palo Alto, CA, 1987. 456 pp., $69.60 cloth, $48.45 paper.

*The Dilemma of Toxic Substance Regulation*l; *how overregulation causes underregulation at OSHA.* John M. Mendeloff. The MIT Press, Cambridge, MA, 1988. 114 pp.

Neptunium: Radiation Protection Guidelines. NCRP Report No. 90. National Council on Radiation Protection and Measurements, Bethesda, MD, 1988. 114 pp.

Hazardous Waste Site Management: Water Quality Issues. Report on a Colloquium Sponsored by the Water Science and Technology Board. National Academy Press, Washington, DC, 1988. 212 pp., $24.50.

Taking Population Seriously - The Missing Piece in the Puzzle. Frances Moore Lapp' and Rachel Schurman. Earthscan Publications, London, UK, 1989. 90 pp., £4.95 paper.

Blueprint for a Green Economy. David Pearce, Anil Markandya, Edward B. Barbier. Earthscan Publications, London, UK, 1989. 192 pp.,£6.95 paper.

Staying Alive. Vandana Shiva, ZED Books, London, UK, 1989. 224 pp., $15.00 paper, $55.00 hardcover.

Squatter Citizen, Life in the Urban Third World. Jorge E. Hardoy and David Satterthwaite. Earthscan Publications, London, UK, 1989. 374 pp., £9.95 paper.

Famine Early Warning Systems, Victims and Destitution. Peter Walker. Earthscan Publications, London, UK, 1989. 196 pp., £6.95 paper.

The Economics of Dryland Management. John A. Dixon, David E. James and Paul B. Sherman. Earthscan Publications, London, UK, 1989. 302 pp.,£14.95 paper.

Rheinisch-Westfälische Akademie der Wissenschaften. Vorträge Reihe N, Volume 363, Klaus Knizia: "Energieversorgung im Spannungsfeld zwischen Utopie und Realität" and Gerd H. Wolf: "Fusionsforschung in der Europäischen Gemeinschaft". Westdeutscher Verlag, Opladen, FRG, 1988. 90 pp., DM24.- paper.

History of Universities, Volume VII: 1988, Laurence Brockliss, Oxford University Press, Oxford, UK, 1989. 472 pp., £45.00 hardcover.

Socialist Somalia. Ahmed I. Samatar. ZED Books, London, UK, 1989. 186 pp., £8.95 paper, £27.95 hardcover.

Understanding Superfund, A Progress Report. Jan Paul Acton, The RAND Corporation, Santa Monica, CA (R-3838-ICJ), 1989. 65 pp., $7.50 paper.

National Security: The Economic and Environmental Dimensions. Michael Renner. Worldwatch Paper 89. Worldwatch Institute, Washington, D.C., 1989. $4.00.

The Bicycle: Vehicle for a Small Planet. Marcia D. Lowe. Worldwatch Paper 90. Worldwatch Institute, Washington, D.C., 1989. $4.00.

Slowing Global Warming: A Worldwide Strategy. Christopher Flavin. Worldwatch Paper 91. Worldwatch Institute, Washington, D.C., 1989. $4.00.

Guidance on Radiation Received in Space Activities. NCRP Report No. 98. National Council on Radiation and Measurements, Bethesda, MD, 1989.

Medical X-Ray, Electron Beam and Gamma-Ray Protection for Energies up to 50 MeV (Equipment Design, Performance and Use). NCRP Report No. 102. National Council on Radiation and Measurements, Bethesda, MD, 1989.

Entwicklung und Erprobung eines aquatischen in vivo-Mutagenitätstests mit Xenopus laevis. Marianne Lehmann. Institut für Wasser-, Boden- und Lufthygiene des Bundesgesundheitsamtes, Berlin, FRG, 1989.

Anwendung der EG-Richtlinie 80/779 am Beispiel eines Schwefeldioxid-Messnetzes und von Schwebstaub-Messtellen in hoch belasteten Berliner Stadtteilen. R. König, L. Laskus, E. Eickeler, F. Mahdjour, E. Lahmann. Institut für Wasser-, Boden- und Lufthygiene des Bundesgesundheitsamtes, Berlin, FRG, 1989.

Viren und Plasmide in der Umwelt, Ausscheidung, Freisetzung, Biotechnologie. J.M. Lopez Pila, E. Seeber and K. Jander, eds. Verein für Wasser-, Boden- und Lufthygiene, Berlin-Dahlem, FRG, ISBN 3-437-30589-1. Gustav Fischer Verlag, Stuttgart/New York, 1988. This volume contains a collection of papers on the environmental aspects of certain microorganisms. While several papers contain experimental data, others are literature reviews. The editors were stimulated by the need to evaluate releases of genetically engineered microorganisms.

Biotechnologische In-situ-Sanierung kontaminierter Standorte. Z. Filip, ed. Verein für Wasser-, Boden- und Lufthygiene, Berlin-Dahlem, FRG, ISBN 3-437-30607-3. Gustav Fischer Verlag, Stuttgart/New York, 1988. The results of a workshop held in Langen in May 1987 are presented in this volume. About half of the presented papers were in English and included both genetically engineered as well as naturally occurring microorganisms. Several field studies were also included.

Pflanzenschutzmittel und Grundwasser, Bestands - aufnahme, Verhinderungs- und Sanierungsstrategien. G. Milde and U. Müller-Wegener, eds. Verein für Wasser-, Boden- und Lufthygiene, Berlin-Dahlem, FRG, ISBN 3-437-30590-5, Gustav Fischer Verlag, Stuttgart/New York, 1989. This volume contains papers presented at a workshop held in Berlin in June 1988. It was apparently stimulated by the limits for pesticides in drinking water of 0.1 µg/L for each pesticide and no more than 0.5 µg/L for all pesticides. The 40 presentations and discussions were mostly in German, but occasionally in English.

Plant Hunting for Kew. F. Nigel Hepper, ed. Her Majesty's Stationery Office, Norwich, UK. 232 pp., £17.95 softback. This beautifully illustrated book takes the reader to many remote parts of the world in search of rare and unusual plant specimens for the famous Kew Gardens near London. It is instructive to the botanist, nature lover, and anyone interested in the activities of plant collectors. The foreword is by Sir David Attenborough.

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NEWS

INTERNATIONAL COMMITTEE FOR RADIONUCLIDE METROLOGY

EI 8910-267N (Received 17 August 1989)

The International Committee for Radionuclide Metrology (ICRM) held its most recent meeting during 5-9 June 1989 in Braunschweig, Federal Republic of Germany.

Activities of the ICRM working groups included a two-and-a-half day symposium on "Nuclear Decay Data, Spectrometric Methods, Measurements and Evaluations", the presentation of over 60 papers to 115 delegates from 23 countries, and a half-day seminar on "Radon Measurements". The latter was followed by a one-day specialists workshop on "Radon Standards: Quality Control and Measurement". The proceedings of the seminar on radon will be published in the Journal of Research of the National Institute for Standards and Technology (NIST), while those of the nuclear data symposium will appear as a special issue of Nuclear Instruments and Methods in Physics Research Section A.

The week's programme included also business meetings of all six ICRM working groups. The final day was devoted to the General Meeting. This meeting welcomed recently appointed members from the Institute of Radiation Protection and Dosimetry (IRD), Brazil, and the D.I. Medeleev All-Union Scientific Research Institute (VNIIM), USSR, and to confirm the appointment of members from the Centre for Standardisation and Radiological Safety Research of the National Atomic Energy Agency of Indonesia and the Standards Research Institute of the Republic of Korea: Twenty-six countries are now represented on ICRM.

It was decided to proceed with publication of an ICRM paper, "Guidelines for International Acceptance of Radioactivity Calibration Sources". This paper had encouraged consideration of extending the International Reference System (SIR) for gamma-emitting radionuclides, operated by the International Bureau of Weights and Measures (BIPM), to other radionuclides. Furthermore, a working party was formed to consider a future role for ICRM in the international certification of radionuclide reference materials.

W. Bambynek, one of the editors of the ICRM Newsletter, summarised the findings of an inquiry on the status of radionuclide metrology in members' countries which he had carried out on behalf of ICRM. The study revealed, inter alia, that, while 75% of member laboratories are funded, at least partly, by government, more than half must recover part of their costs. Among ICRM member laboratories over 300 people are employed in radionuclide metrology, a minute fraction of the population which benefits from their activities. In only 38% of member countries are there as yet regulatory requirements for traceability, i.e. for radioactivity measurements to be related to national standards. In all countries the becquerel is now the legal unit of radioactivity; the curie is still permitted in six member countries and remains in use unofficially in many others.

For the future, it was agreed that the 1991 meetings will include a joint seminar of the Life Sciences and Techniques in Radionuclide Metrology working groups. These meetings will take place in Madrid during 27-31 May, at the invitation of the Centro de Investigaciones Energeticas Medioambientales y Tecnologicas (CIEMAT). It was also agreed that a joint meeting of the Low Level Techniques and Alpha Particle Spectrometry working groups will be held, in association with the 1991 meetings, at a location yet to be decided.

The following appointments of officers of ICRM were confirmed effective 9 June 1989:

Executive Board:		
President	P. Christmas	Div. of Radiation Science and Acoustics National Physical Laboratory Teddington, Middlesex TW11 0LW, U.K.
Vice Presidents	K. Debertin	Physikalisch-Technische Bundesanstalt, Bundesallee 100, BP 3345 D-3300 Braunschweig, FRG
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Secretary	D.D. Hoppes	National Institute of Standards and Technology, Radioactivity Group Gaithersburg, MD 20899, U.S.A.
Working Group Coordinators:		
Non-neutron nuclear data	A.L. Nichols	AEA Technology, Technology Div. A50 Winfrith Dorchester, Dorset DT2 8DH, U.K.
Low level measurement techniques	J.M. Hutchinson	National Institute of Standards and Technology Gaithersburg, MD 20899, U.S.A.
Alpha particle spectrometry	G. Bortels	CEC-JRC Central Bureau for Nuclear Measurements B-2440 Geel, Belgium
Gamma and beta ray spectrometry	R.G. Helmer	Idaho National Engineering Laboratory EG&G Idaho Inc. P.O.Box 1625 Idaho Falls, ID 83415 U.S.A.
Life sciences	K. Ennow	National Institute of Radiation Hygiene National Board of Health 378 Frederikssundsvej DK-2700 Bronshoj, Denmark
Techniques in radionuclide metrology	T. Radoszewski	Instytut Energii Atomewej, Osrodek Reaktorow i Produkeji Izotopow Zaclad Doswiadczalny, P1-05-400, Otwock, Swierk, Poland

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ICRM aims to encourage the dissemination of information on techniques and applications of radionuclide metrology, and to advance international cooperation in this field. Members of ICRM represent national laboratories responsible for radionuclide standards, or international organisations concerned with radionuclide metrology.

The scientific activities of ICRM are largely the responsibility of the working groups: those wishing to participate in these activities, or to receive further information are encouraged to contact any of the ICRM officers listed above.

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ERRATUM

The list of editors which appeared in Volume 14, Number 6 (1988) and Volume 15 (1989) contains several errors. The correct list appears in this issue. We regret these errors.

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NEW PATENTS

This Section contains abstracts and, where appropriate, illustrations of recently issued United States patents and published patent applications filed from over 30 countries under the Patent Cooperation Treaty. This information was obtained from recent additions to the Pergamon PATSEARCH™ online database in accordance with interest profiles developed by the Editors. Further information about Pergamon PATSEARCH™ can be obtained from Pergamon Orbit InfoLine Inc., 8000 Westpark Drive, McLean, Virginia 22102 U.S.A.

Copies of complete patents announced in this Section are available from Pergamon Orbit InfoLine Inc. for $8 per copy. Payment with order is required. Orders outside North America add $2 for air postage. Order by patent number for Pergamon Orbit InfoLine only.

4754726

EMISSION CONTROL APPARATUS

Trevor L Eller, Stawell, Victoria, Australia

Apparatus to reduce exhaust pollution of internal combustion engines (12) comprises a manifold (26) connected to the cells of the battery (23) of the electrical system associated with the engine (12), the manifold (26) receiving gas/vapor emitted from the battery cells. The manifold (26) is connected by a line (27) to the fuel/air inlet manifold (14) of the engine (12), preferably via the gas recirculation line (22) connecting the crankcase ventilation to the inlet (14). Water vapor taken from the engine radiator (31) can also be drawn into the line (27) through an accumulator (28). A second battery (34) can also be connected to the accumulator (28) to increase the gas/vapor drawn into the inlet (14).

4757201

DOSIMETER FOR MONITORING FOOD IRRADIATION

Ira E Kanter assigned to Westinghouse Electric Corp

A device for monitoring the irradiation of bulk material composed of a carrier body having an outer surface formed to present a plurality of facets and constructed to receive a radiation sensor on each facet; and a plurality of radiation sensors each removably mounted on a respective facet of the carrier body.

4758308

SYSTEM FOR MONITORING CONTAMINANTS WITH A DETECTOR IN A PAPER PULP STREAM

Wayne F Carr

In a contaminant detector for processing paper pulp including sticky contaminants, a pulp sample is diluted to less than 0.5% consistency and passed through a concentrator from a plurality of classified samples having heavy and light particles. The inclined classified samples are again diluted to less than 0.5% consistency and passed as thin sample flow through an open channel having a light transmitting base. The flow is back lighted and a photodetector includes a linear array of sensitive elements aligned to receive the transmitted light. The sensitive elements aligned with particle creates a signal proportional to the width. By rapid sequential activation of the elements, a digital data stream is created which is processed by a microprocessor to determine the particle size and produce a plurality of contaminant relative signals related to different classified size ranges, such as heavy, medium and small contaminant particles. A particle removal includes sequential stages for successively removing the heavy, medium and small sized contaminants, with a control for each stage. The pulp sample is taken at a highest concentration location and the contaminant related signals are connected to actuate the corresponding controls for the several stages.

4759844

PORTABLE WATER PURIFICATION SYSTEM

Mitchell Lipschultz, Alfred J Liptschultz assigned to Aquathin Corp

An apparatus for purifying drinking water by a combination of reverses osmosis, deionization by ion exchange resins, resin and final passage through activated carbon. The components for reverse osmosis, de-ionization, and passage through active carbon, and a product water reservoir are housed in a cabinet suitable for placement in a home. Ionic impurities are removed by reverse osmosis through a cellulose acetate membrane which feeds the flux water to a mixed resin bed for deionization. Waste brine is removed from the reverse osmosis module by controlled leakage to maintain concentration at a low level. The product water is filtered through a cartridge of granular activated carbon prior to being stored in a product water reservoir. An attachment is connectable with the tap water faucet to provide tap water to the unit at main water supply pressure and to dispose of waste brine water and excess product water. Components are replaceable and available on the market.

4761132

OXYGEN ENRICHED COMBUSTION

Mark J Khinkis assigned to Combustion Tec Inc

A process and apparatus for oxygen-rich combustion wherein a first portion of about 5 to about 40 percent of the total fuel to be cracked and combusted is introduced to a cracking chamber where it is combusted and cracked at a temperature below about 2200 degrees C. to produce a cracked products mixture. Oxygen-rich gas of greater than about 30 volume percent oxygen is introduced to the cracking chamber in about 5 to about 50 percent of the stoichiometric requirement for complete combustion of the first portion of fuel introduced to that chamber. Cracked products mixture, a second remaining portion of fresh fuel and oxidizer having sufficient oxygen for substantially complete combustion of the combustible portion of the cracked products mixture and the fresh fuel is introduced to a combustion chamber wherein the combustible portion of the cracked products mixture and the fresh fuel is combusted. The process and apparatus provide a controllable, highly luminous, high temperature and high kinetic energy flame in the combustion chamber resulting in enhanced heat transfer rate to the furnace load, increased furnace specific production rate, increased furnace thermal efficiency, and reduced nitrogen oxides pollutant emissions.

4761965

EVAPORATIVE ROOF COOLING SYSTEM

Stephen G Viner

An evaporative roof cooling system for placement upon a roof surface exposed to relatively high levels of solar radiation. The system includes water distribution piping and a plurality of mist/spray nozzles positioned on the roof surface for supplying a uniform spray of water thereover to lay down a substantially uniform thin film of water on the roof surface. A solenoid-controlled valve controls the supply of water to the system over periods during which the temperature of the roof surface is measured to be within a predetermined temperature range. A thermistor, encapsulated in an expoxy block, is affixed to the roof surface and monitors and measures the actual roof temperature. Cooling systems control circuitry, in electric communication with the thermistor and the solenoid-controlled valve, compares the electric resistance value developed by the thermistor and a range of current values related to the predetermined temperature range and directs the opening of such valve when the termister senses the high point temperature of such range and the closing of such valve when the thermister senses the low point temperature of such range whereby the mist/sprays of water discharged from the nozzles evaporatively cool the roof surface.

4765807

METHOD AND APPARATUS FOR THE OXYGEN ENRICHMENT OF WATER

Norolf Henriksen, Notodden, Norway assigned to Norsk Hydro a s

A system for the treatment of liquids, especially oxygen enrichment of water which is used for aquaculture purposes such as the breeding of fish, avoids gas bubbles in a water reservoir and makes it possible to freely treat fresh water and/or recirculated water for optimal temperature control and/or water removal. A water flow is joined with a flow of pure oxygen gas which is supplied from an oxygen tank containing liquid oxygen. The oxygen is led through an evaporator into a flow system forming a recirculating circuit with pipelines, and an oxygen enrichment device or reactor unit where water and oxygen are mixed to form a turbulent, foaming gas/liquid

flow mixture. Such mixture is subsequently led into a gas/liquid separator where gas and liquid are separated. The gas mixture from the separator, which now in addition to oxygen also will contain contaminants such as nitrogen and carbon dioxide, is recirculated by means of a compressor. To prevent the build-up of great amounts of nitrogen and other contaminants, there is provided a deaeration device in the form of a bleed or in the form of a special separation unit.

4767929

EXTENDED RANGE RADIATION DOSE-RATE MONITOR

Kenneth H Valentine assigned to The United States of America as represented by the United State Department of Energy

An extended range dose-rate monitor is provided which utilizes the pulse pileup phenomenon that occurs in conventional counting systems to alter the dynamic response of the system to extend the dose-rate counting range. The current pulses from a solid-state detector generated by radiation events are amplified and shaped prior to applying the pulses to the input of a comparator. The comparator generates one logic pulse for each input pulse which exceeds the comparator reference threshold. These pulses are integrated and applied to a meter calibrated to indicate the measured dose-rate in response to the integrator output. A portion of the output signal from the integrator is fed back to vary the comparator reference threshold in proportion to the output count rate to extend the sensitive dynamic detection range by delaying the asymptotic approach of the integrator output toward full scale as measured by the meter.

4768024

APPARATUS FOR MONITORING FIRE HAZARDS IN A BUILDING

Werne Hauff, D 7925 Ballmertshofen, Federal Republic Of Germany

The apparatus for detection of fire in a building includes at least one duct for at least one cable, particularly an electrical cable, through a wall opening in one of the walls of the building. The duct having two sealing members sealing the wall opening on both sides of the wall against the cable and the wall of the cable-feed passage is a fire retardant seal, by which the line of the cable is sent between different fire zones separated by the wall from each other while preventing the spread of fire between the fire zones. At least one electrical temperature sensor is mounted inside of the duct and at least one electrical connecting conductor connecting the temperature sensor and a detection device for direct detection of a sensor signal from the temperature sensor is guided from the interior of the duct to the wall and is fire protected in the wall. The duct with the sensors and the connecting conductors are embedded in the wall of the building during its manufacture. Additional sensors including smoke or gas detectors and a plurality of variously positioned temperature sensors can also be provided.

4769131

ULTRAVIOLET RADIATION PURIFICATION SYSTEM

John R Noll, Stephen V Montvila assigned to Pure Water Technologies

A fluid purification system includes an elongated ultraviolet radiation emitting tube and independent fluid flow-controlling conduits. Each conduit is transparent to allow ultraviolet light emitted by the tube to enter the conduit, and defines a continuous, aand is helically wound closely about the tube to insure that fluid flow through the conduits is exposed to the ultraviolet light. The system includes a filter having inlet and outlet ports. An end of each conduit is connected to one of the inlet and outlet ports of the filter. The system thus exposes the fluid to ultraviolet radiation both before and after the fluid is filtered.

4769547

PERSONAL DOSIMETER HAVING A VOLUME OF GAS ATOP AN INTEGRATED CIRCUIT

Arthur E Uber assigned to Medrad Inc

A dosimeter that includes tissue equivalent bubbles of plastic defining volumes of gas to be ionized by radiation. One or more integrated circuits (ICs) are disposed below the volumes of gas and a collecting electrode on the IC is in direct contact with the gas. Circuitry for generating an electric field within the volume of gas moves the ions therein to the collecting electrode. The col-

lecting electrode is part of an amplifying circuit disposed within the IC. The output from the amplifier is representative of the collected ions and therefore representative of the radiation. The signal from the amplifier is sent to an interface which conditions, buffers and stores the signal. The radiation dose and dose rate are computed in the interface. A communications section transfers that data from the dosimeter upon receipt of an externally generated data transfer command. A separate calibration and display unit calibrates the dosimeter by controlling the conditioning of the signal.

4773252

GAS MONITORING EQUIPMENT

Gyula Jarolics, Copenhagen, Denmark assigned to F L Smidth & Co A/S

Equipment for monitoring the concentration of components in a gas flow has two probes (1,2) located at (63) in the gas flow. Sample gas is drawn through the probes and through pipes (3,4) by a pump (8), and test samples are extracted from the pipes by pumps (11,12) and fed to an analysis line (10). The probes (1,2) work alternately, and, when one is not working, it may be cleaned by blowing air through from a source (9), while the corresponding one of the pipes (3,4) is blocked from the line (10) by valves (13-16).

4774006

FLUID TREATMENT METHOD

Leonard A Kaufmann assigned to VerTech Treatment Systems Inc

The subterranean treatment apparatus and methods disclosed herein are useful for treating various waste streams, including municipal and industrial streams. The disclosed apparatus and methods are particularly useful in determining and controlling the temperature of the reaction zone in a deep well reaction apparatus while avoiding fouling of thermocouples and permitting easy service and replacement. In the disclosed embodiment, a fluid quiescent zone is created in the heat exchanger of the treatment apparatus located within the reaction zone and the temperature is used to control the system by operation of the heat exchanger or control of the C.O.D. of the influent.

4774021

PARTIAL OXIDATION OF SULFUR-CONTAINING SOLID CARBONACEOUS FUEL

Mitri S Najjar, Roger Corbeels assigned to Texaco Inc

A process for the simultaneous partial oxidation and desulfurization of sulfur and silicate-containing solid carbonaceous fuel for the production of gaseous mixtures comprising H2 and CO and containing less than about 0.05 volume % of H2S and COS. In the process, an aqueous slurry of the solid carbonaceous fuel and a copper-containing compound are reacted by partial oxidation in the reaction zone of a free-flow unobstructed down-flowing vertical refractory lined gas generator with a controlled amount of free-oxygen containing gas and with optionally a temperature moderator so that an equilibrium oxygen concentration is provided in the gas phase in the reaction zone having a partial pressure which is less than about 10-6 atmosphere. The O/C atomic ratio is in the range of about 0.5 to 2.0. The H2O/solid carbonaceous fuel weight ratio is in the range of about 0.2 to 0.7. Further, the total moles of copper in the reaction zone is at least equal to about 1.0 times the moles of sulfur in the solid carbonaceous fuel. The partial oxidation and desulfurization reactions take place simultaneously at a temperature which produces fly-ash or molten slag at an increased thermal efficiency. At least about 90 wt. % of the sulfur in the solid carbonaceous fuel in the reaction zone is converted into copper oxysulfide particulate matter which leaves the reaction zone along with the fly-ash or molten slag entrained in the hot raw effluent gas stream comprising H2, CO, CO2 at least one gas selected from the group consisting of H2O, N2, CH4 and A; and less than about 0.05 volumne % of H2S and COS. The mole ratio in the reaction zone for H2O/H2 is in the range of about 0.4 to 3.0.

4775516

APPARATUS FOR MONITORING THE CARBON CONTENT OF BOILER FLUE ASH

Roger D Kempster, Peter A E Crosse, Betchworth, United Kingdom assigned to Central Electricity Generating Board

A carbon-in-ash monitor uses a fluidized bed furnace to burn any carbon in sampled boiler flue ash and evolve carbon dioxide therefrom. Fluidizing gas (air) is provided to the bed a measured flow rate and a batching arrangement feeds successive batches of ash of measured mass to the furnace at a measured frequency. A CO2 monitor measures the amount of CO2 evolved to determine the carbon content of the ash. Batches are provided using a vibratory table to transport ash from a point of supply to the table and a point of delivery of ash in a stream from the table. The vibratory table is horizontal and is driven so that the mode of vibration can be selected to reverse the direction of ash transport.

4779207

SO3 FLUE GAS CONDITIONING SYSTEM

David L Woracek, Robert A Wright assigned to The Chemithon Corporation

An air pollution control system for injecting a conditioning agent into the flue gas of a power generator. The conditioning agent changes the resistivity of particulate matter in the flue gas, rendering the particulate matter more easily able to accept an electrostatic charge. Control of the conditioning gas injection rate is monitored by periodically sampling the average input power supplied to the power supplies of the electrostatic flue gas conditioning system. A proportional-integral controller receives the signal representing the difference between the average input power and a predetermined threshold signal. The control signal produced by the proportional integral controller causes incremental changes in the rate at which the conditioning agent, such as SO3, is added to the flue gas.

4779524

APPARATUS FOR CONTROLLING THE RIPENING OF FRESH PRODUCE

William Wade assigned to Nabisco Brands Inc

In a method and apparatus for controlling the ripening of fresh fruit, a stack of fruit boxes is spiral wound with a transparent synthetic resin strip around the four vertically oriented faces of the box stack. The boxes within the stack have openings on their upper and lower faces which register with corresponding openings in vertically adjacent boxes to permit a vertical movement of an air-ethylene mixture through the stack. A plastic cap or lid is disposed on top of the stack of boxes and is provided with a blower for drawing air vertically through the stack from the bottom thereof. An air-conditioning unit and an ethylene containing bottle may be disposed in a unit on which a pallet supporting the stack of boxes rests. Effluent air or a mixture of air and ethylene is fed back to the air-conditioning unit via a conduit on the outside of the wrapped stack of boxes.

4780479

INSECT BEHAVIOR MODIFYING COMPOUNDS

John A Pickett, Ewen D M Macaulay, Hitchin, United Kingdom assigned to National Research Development Corporation

Derivatives of carbonyl-group containing behavior modifying compounds, in which said carbonyl group has been converted to a photolabile group which regenerates the carbonyl group on exposure to radiation, are of value in various methods for the control of animal, and in particular insect, species.

4780989

HYDROPONIC ASSEMBLY

Stowell W Mears, Kri Johnson, Yves Kraus assigned to Mears Structures Inc

An integrated hydroponic system including subsystems for support and movement of plants, controlling the atmosphere around the plants and nutrient distribution. The support and movement subsystem features diverging trough-in-trough construction where the interior trough is formed by discrete autoclavable plastic troughs which are slidably removable for sanitation purposes from supporting exterior troughs which in turn support nutrient distribution tubing and a rotatable variable pitch drive screw for moving individual plant holders along the troughs in graduated increments. The atmospheric control system features supply and exhaust ducts under the troughs which establish a blanket of air in the zone proximate to the trough where the temperature, humidity and carbon dioxide concentration are regulated. The nutrient distribution system involves recycling

the thermally and component regulated dilute nutrient fluids from a reservoir to the plants and back into the reservoir.

4781027

MULTI-CYLINDER INTERNAL COMBUSTION ENGINE WITH TWO EXHAUST GAS TURBOCHARGERS

Axel Richter, Jochen Lorenz, Ulrich Eger, Wimsheim, Federal Republic Of Germany assigned to Dr Ing h c F Porsche Aktiengesellschaft

A multi-cylinder internal combustion engine with two exhaust gas turbochargers of which one is adapted to be switched-in during the operation of the internal combustion engine by way of a switch-in valve controllable on the turbine side and by way of a check valve on the compressor side. Furthermore, a controllable blow-off valve (waste gate) is installed into a by-pass line which by-passes both turbines. The blow-off valve and the switch-in valve are controllable by a control apparatus as a function of condition magnitude of the internal combustion engine. The activation of the blow-off valve and of the switch-in valve is subjected to an anticipatory control dependent on condition magnitudes on which at least one charging-pressure-dependent regulation is superimposed. The regulation has advantageously a PID-like structure whereby the regulating parameters are condition-dependent. The regulation and control are additionally subjected to static as well as dynamic limitations. A noticeable improvement of the power output, respectively, torque behavior of the internal combustion engine results from the deliberate control and regulation of the charging system.

4781165

INTERNAL COMBUSTION ENGINE POLLUTANT CONTROL SYSTEM

Kelly R Rawlings assigned to Anti-P Inc

A carburetion system for an internal combustion engine includes a fuel heater and vaporizer unit which produces a 30% liquid/70% vapor fuel mixture for delivery to the carburetor, and a flow control valve connected to be responsive to the ported vacuum pressure in the carburetor to increase the flow of heated and vaporized fuel to the carburetor when the ported pressure decreases, and decrease the flow of such heated and vaporized fuel when the ported pressure increases. The air drawn into the carburetor as a result of engine operation is further heated to a temperature within the range 160 degrees F. to 180 degrees F., by thermister controlled heating elements. In operation, the flow control valve works in conjunction with the carburetor float chamber to provide varying amounts of heated liquid fuel and heated vaporized fuel for mixing within the carburetor with the heated air, to enhance combustion within the engine and produce a corresponding reduction in exhaust pollutants.

4781805

METHOD FOR CONTROLLING POLLUTION AND REDUCING CALCIUM CONCENTRATION IN AQUEOUS BODIES

Vincent Dahlgren

An improved method of controlling algal and bacterial pollution, as well as reducing the concentration of dissolved calcium, in a swimming pool, without the necessity of adding electrolytes thereto, involving the steps of: (a) conveying a stream of water from the swimming pool to an enclosed area and back to the pool; (b) providing a pair of spaced-apart electrodes in the enclosed area through which the water is to pass, the electrodes being chemically active and made from mixtures of silver and aluminum alloy containing from about 0.5 to about 5.0 per cent by weight silver and the valance being aluminum alloy; (c) providing a source of alternating electrolytic potential to the electrodes to generate an energy field through the water stream between the electrodes having an rms voltage range from about 25 to about 35 volts and a frequency of alternation of 60 cycles per second to toxify the bacteria and algae in the water and to agglomerate the dissolved calcium into filterable agglomerates; and, (d) providing a filter downstream from the electrodes in the enclosed area for filtering the water as it passes from the electrodes and before it returns to the swimming pool.

4782766

AUTOMATIC COMBUSTION CONTROL FOR A ROTARY COMBUSTOR

Suh Y Lee, William G Collins, John T Healy assigned to Westinghouse Electric Corp

A combustion controller controls the supply of combustion gas to the combustion barrel of a rotary combustor used for incinerating solid waste material. The rotary combustor includes a combustion barrel having a gas-porous side wall and windboxes underneath the combustion barrel to supply the combustion gas to support incineration of the waste material into combustion products which include exhaust gases. The windboxes receive combustion gas via individual control ducts which are controlled by the combustion controller to regulate the corresponding supplies of combustion gas and thereby to provide substantially complete incineration of the solid material. An oxygen sensor detects the percentage of oxygen present in the exhaust gases and the combustion gas supplied to the combustion barrel is controlled to maintain the percentage of oxygen near a predetermined level. In addition, flame and temperature sensors may detect temperature and the existence of a flame, respectively, in an area above each of the windboxes, so that the combustion gas supplied to each windbox can be individually controlled.

4782773

METHOD FOR CONTROLLING INCINERATION IN COMBUSTOR FOR RADIOACTIVE WASTES

Yoshinobu Takaoku, Akio Uehara, Tokorozawa, Japan assigned to Sumitomo Heavy Industries Ltd

Complete incineration of combustible radioactive wastes in the combustor can be regulated in the manner of controlling the flow rate of supplemental fuel fed to the combustor so that the outlet gas temperature of the combustor may be maintained at the set temperature; and increasing or decreasing the supply amount of wastes in response to said increase or decrease of said flow rate.

4782816

APPARATUS FOR A SOLAR WATER HEATER

Angel M Salgado, Harold L Drury

A solar water heater has a basin or reservoir for collection and storage of heated water, a generally pyramidal or prism shaped structure for absorbing solar radiation, a transparent pyramidal or prism shaped structure for enclosing and thermally isolating the reservoir and radiation absorbing element, a pump and associated apparatus for projecting the water against heat absorbing structure and a valve for controlling the flow of heated water from the reservoir. The heat absorbing structure and the enclosing structure are comprised of a multiplicity of planar elements that can be disassembled for transport or for storage. The power consumption from external sources for operating the solar heating device can be reduced by providing a battery and by using air, expanded through the process of heating the water, to drive an electrical generator, the generator charging the battery.

4783326

PROCESS FOR THE REMOVAL OF POLLUTANTS FROM HOT GASES

Franz-Gerhard Srednicki, Brunswick, Federal Republic Of Germany assigned to ERA GmbH

A process for the removal of pollutants from hot flue gas is disclosed. The gas is cooled and at specified temperatures various acids are condensed out. After a further cooling, heavy metals are removed. Precise control of the quantity of water in the flue gas results in a purification process that is highly efficient. By adjusting the content of free oxygen in the flue gas, the addition of oxidizing agents used to remove sulfur dioxide can be considerably reduced.

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SOFTWARE SURVEY SECTION

Editor's Note: The following Software Descriptions have been submitted by our readers in response to our call for an open exchange of information on software programs. They are offered without review or comment to provide a rapidly published, easily accessible avenue of communication. Other readers with relevant software packages are invited to complete and submit a Software Description Form (found at the end of this section).

Software package EI-057-S90 CAPTURE

Contributor: Sven Alenins, National Institute of Occupational Health, ITV, 17184 Solna, Sweden

Brief description: CAPTURE is a program for particle transport study. Using the program you will be able to:

1. Define and draw local exhausts or particle sampling inlets. Opening geometries are circular flanged or unflanged and rectangular flanged. Sizes, air flows, locations and orientations may be varied.
2. Define a cross wind and/or circular air jet.
3. Superimpose defined air flow fields and calculate air velocities.
4. Present calculated air flow fields graphically as velocity vectors.
5. Define a particle source geometry, particle sizes, densities and starting velocities.
6. Calculate and draw particle trajectories.

The studied situation is presented graphically in three perpendicular views. View and visualization parameters may be changed and the images redrawn. Cost of program is $1000.

§ This application program in the area of particle transport simulation has been developed for IBM AT or compatible in FORTRAN 77 to run under MS-DOS. It is available on 5-1/4", single-sided, single-density floppy diskette. Required memory is 500K.
§ Distributed by National Institute of Occupational Health.
§ The minimum hardware configuration required is Co-processor 80287, EGA-graph. User training is required. There is extensive external documentation. Source code not available.
§ The package is fully operational. It has been in use at 7 sites for approximately 5 months. The contributor is available for user inquiries.

X Software Survey Section

JOURNAL NAME ENVIRONMENT INTERNATIONAL

P E R G A M O N P R E S S
SOFTWARE DESCRIPTION FORM

Title of software program: _____

_____

Type of program: [ ] Application [ ] Utility [ ] Other_____

Category: _____ (ie. Psychological assessment, statistics, thermodynamics, etc.)

Developed for (name of computer/s): _____

in (language/s):_____

to run under (operating system): _____

available on: [ ] Floppy disk/diskette. Specify:

Size _____ Density _____ [ ] Single-sided [ ] Dual-sided

[ ] Magnetic tape. Specify:

Size _____ Density _____ Character set _____

Hardware required: _____

Memory required: _____ User training required: [ ] Yes [ ] No

Documentation: [ ] None [ ] Minimal [ ] Self-documenting
[ ]Extensive external documentation

Source code available: [ ] Yes [ ] No

Stage of development: [ ] Design complete [ ] Coding complete
[ ] Fully operational [ ] Collaboration welcomed

Is program in use? [ ] Yes How long? _____ How many sites? _____
[ ] No

Is the contributor available for user inquiries: [ ] Yes [ ] No

Distributed by: _____

Cost of program: _____

Demonstration disk available? [ ] Yes Cost: _____
[ ] No

(continued)

RETURN COMPLETED FORM TO:

Ms. Barbara Moghissi
Environment International
P.O. Box 7166
Alexandria, VA 22307

Description of what software does [maximum: 200 words]:

Potential users: _____

Field/s of interest: _____

# # # # # # #

Name of contributor: _____

Institution: _____

Address: _____

_____

Telephone number:_____

# # # # # # #

Reference No. [Assigned by Journal Editor] _____

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Would you like to have your program:

Reviewed? [ ] Yes [ ] No [ ] Not at this time

Marketed and distributed? [ ] Yes [ ] No [ ] Not at this time

THE RECURRING SILENT SPRING

by H. Patricia Hynes
Institute on Women and Technology, North Amherst, MA

". . No other book shows so ably the struggle Rachel Carson faced and explores so brilliantly the social and political dimensions of her pathbreaking work. Hynes holds up **Silent Spring** like a delicate crystal and directs its timeless insights to illuminate today's environmental problems."
Sheldon Krimsky, Ph.D., Department of Urban and Environmental Policy, Tufts University

"Pat Hynes has written a book to slap the smirk off the face of conventional environmentalism. As the global environment continues to deteriorate under the relentless onslaught of a macho-industrial society, let us hope her call to a higher moral plane is heeded in time."
Patrick A. Parenteau, Commissioner, Vermont Department of Environmental Conservation

"I kept wishing, as I read **The Recurring Silent Spring,** that Rachel Carson were alive to read it too. In its breadth and depth of research, its worldliness, its passionate intelligence and its moral fierceness, it is (a) book fully worthy of Rachel Carson.

Patricia Hynes draws on the principles of environmental protection inspired by **Silent Spring** to make the soundest policy recommendations on the new reproductive technologies I have ever read — policies centered on women's right to dignity, bodily integrity and self-defined existence.

The Recurring Silent Spring is an essential book for anyone concerned about genetic engineering and reproductive technologies. Her analysis of them, learned by studying the development of the atomic bomb, gives us the tools we need to think and act our way onto the paths less traveled by — the paths, as Hynes writes, that 'offer our last, our only chance to reach a destination that assures the integrity of earth and ourselves.' "
Gena Corea, Author of **The Mother Machine**

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drinking water treatment

SMALL SYSTEM ALTERNATIVES

Proceedings of the Third National Conference on Drinking Water, St John's, Newfoundland, Canada, 12-14 June, 1988

This volume presents the entire proceedings of the Small System Alternatives conference. The conference brought together practitioners, regulatory personnel, and researchers from six countries. Discussions concerned all aspects of design, construction and operation of small systems for the provision and treatment of drinking water. Information on both existing and emerging technologies was presented, examiningstate-of-the-art small drinking water systems and exploring possible future directions. The program included 21 oral and 6 poster presentation, and concluded with a panel discussion on problems and solutions. There was particular attention paid to operation of systems in cold climates in remote and semi-remote areas.

EDITORS

P Toft, *Environmental Health Centre,Tunney's Pasture, Ottawa, Ontario, Canada;*
R S Tobin, *Environmental Health Centre, Tunney's Pasture, Ottawa, Ontario, Canada;*
J Sharp, *Memorial University, St John's, Newfoundland, Canada*

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Disinfection with mixed oxidant gases generated on site (MOGGOD), **F M Reiff.**

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Development of a water supply and water treatment system for a small rural community, **J A Gillies & T Brunas.**

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ENVIRONMENT INTERNATIONAL

Aims and Scope

Environment International, published bimonthly, is a multidisciplinary forum for the publication of original environmental literature. Vital data, causes of pollution, and methods for protection are all featured. Covering the entire field of environmental protection, *Environment International* includes contributions from the following areas:

- Concentration of elements and compounds, notably pollutants
- Release rates of pollutants from various sources
- Transport of pollutants in the environmental media
- Health and ecological effects of pollutants
- Control technologies
- Description and interpretation of laws, regulations, and standards
- Information which will contribute to the understanding of environmental behavior of pollutants or will promote environmental protection
- Public policy alternatives including legislation
- National and international recommendations and practices to help bring about a lasting improvement in environmental protection

From time to time *Environment International* will publish issues devoted exclusively to special topics, e.g., specific pollutants. These issues will discuss such problems as environmental concentrations, health and ecological effects, environmental kinetics, production and release rates, legislative and regulatory aspects, control technologies, and other pertinent data. Other special issues will be devoted to pollution problems in selected geographical areas. Authors and readers are encouraged to send in suggestions to the Editor-in-Chief recommending topics for these topical issues.

Information for Contributors

Since the journal will serve a multidisciplinary audience, authors are urged to write for nonspecialists. In particular, they are discouraged from using expressions which are understandable only to a select audience. Clarity should be the guide when preparing manuscripts. All the contributions will be subjected to peer reviews. Owing to the broad coverage of *Environment International*, no single format can accommodate all contributions. Manuscripts must be submitted in English. Mail manuscripts to the Editor-in-Chief. *Environment International*, P.O. Box 7166, Alexandria, VA 22307, U.S.A. The following categories of contributions will be considered for publication in the journal:

Articles — Previously unpublished information including data from routine monitoring operations will be published in this category. Papers dealing with new analytical techniques should contain data indicating their usefulness in environmental measurements. Similarly, basic biological effects data should be related to environmental pollutants.

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Article: Repace, J. L.; Lowrey, A. H. A quantitative estimate of nonsmokers' lung cancer from passive smoking. Environ. Int. 11:3–22; 1985.
Report: NIH (National Institutes of Health). Report of the National Institutes of Health ad hoc working group to develop radioepidemiological tables. NIH 85-2748. Washington, D.C.: U.S. Department of Health and Human Services; 1985.
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