IRCWD NEWS

WHO International Reference Centre for Wastes Disposal

Ueberlandstrasse 133, CH-8600 Duebendorf/Switzerland

"IRCWD News" is issued on the sole responsibility of the WHO International Reference Centre for Wastes Disposal; it does not necessarily reflect the official views and policies of the World Health Organization

No 4

October 1972

Waste Management in Perspective

By Dr. Paul V. Roberts of the Swiss Federal Institute for Water Resources and Water Pollution Control, Duebendorf/Switzerland.

Introduction

The last decade has witnessed a remarkable increase in the breadth and depth of awareness of environmental problems. The development and implementation of rational waste management plans has progressed significantly, especially in the industrialized countries. Strategies for "pollution control", "environmental protection", and other waste management endeavours have become increasingly farreaching, complex, and demanding of public funds. Policy making has matured to the point where waste management strategies are no longer restricted to individual media (air, water, or land), but rather take into account the web of interrelationships among air, water, and land pollution and corresponding pollution control measures.

In view of such admirable progress, it is ironic that the very foundations of today's waste management be challenged, yet such is the case. The substance of the challenge is that our philosophy of waste management is too narrow, that it fails to consider important interactions among waste management, resource management, economic growth, and population growth.

Much of this criticism has shown an apparent lack of objectivity, and its persuasiveness has suffered as a result. Recently the quality of the debate has been upgraded by the appearance of the first quantitative, comprehensive study of environmental problems on a world-wide basis. A multidisciplinary group centered at Massachusetts Institute of Technology (USA) has endeavoured to piece together the complex interrelationships among the principal determinants and indicators of environment quality. The methodology and preliminary results of the group's work are described in the recently published book, "The Limits to Growth" [1].

The Systems Analysis Approach

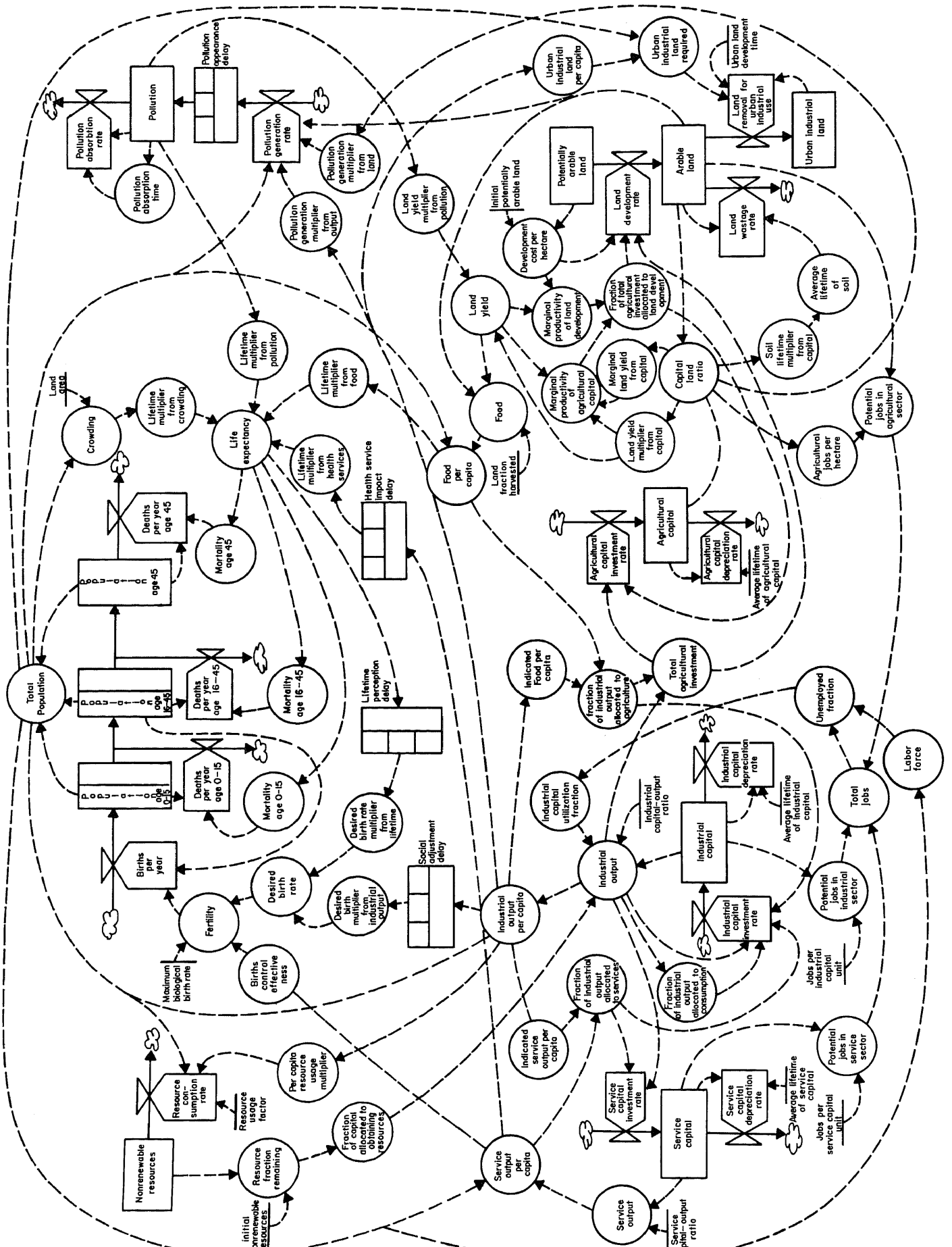
The methodology used in the "Limits to Growth" project may be described as the systems analysis approach. What does "systems analysis" mean in this context?

It is hard to reach general agreement on a definition of systems analysis. What it is and how it ought to be used (if at all) is a point still debated vigorously in many quarters. Therefore, let us limit ourselves to a working definition appropriate for the case at hand. The important characteristics of the methodology are:

1. Clear formulation of alternative strategies and emphasis on their consequences
2. Careful consideration on interactions among phenomena and of time delays that affect system dynamics
3. Due attention even to those variables that are difficult to quantify
4. Construction of a logical model that permits quantitative prediction of future conditions resulting from present actions (or inactions)
5. Testing the validity of the predictions by sensitivity analysis (a technique in which a model's input parameters are changed to determine the effect of an error in its basic assumptions).

The project group has adhered to the above principles remarkably well, considering that this work represents a first attack on a monumental problem.

Figure 1 **The world model**



The complexity of the logical model used as a basis for computation in "Limits to Growth" is shown by this figure. Its detailed model-structure is beyond the scope of this article.

The foundation of the world model lies in the submodels of industry and agriculture, which are based in large part on the work of Prof. Jay Forrester in simulating economic systems on a global scale [2]. The "Limits to Growth" model consists of a total of five submodels – resources, agriculture, industry, population, and pollution.

The model is portrayed schematically in Figure 1. Figure 1 is meant only to communicate an idea of the model's complexity. To describe its structure in detail is beyond the scope of this article. Nevertheless, even in this simple pictorial depiction one notes the large number of feedback loops and other connections among system elements, many of them crossing subsystem boundaries.

On the basis of this model, with all interrelationships quantitatively specified, it is possible to simulate into the future the change in the important outputs

- population
- remaining resources
- food production per capita
- industrial production per capita
- pollution.

These output variables are plotted as a function of time in Figures 2, 3, 4, and 5. Each graph corresponds to a different set of assumptions regarding availability of resources, the effectiveness of population and pollution control measures, and strategies with respect to industrial and agricultural development.

Results of the Simulation

Let us assume that there is no change in the basic ground rules of economic and population growth. It is further assumed that there exists in 1970 a 250 year supply of resources at current consumption rates, and that population and per capita industrial output continue to grow at the 1900 to 1970 rate.

Under these assumptions, the model predicts the response shown in Figure 2, a simple extrapolation of the present trend into the future. Industrial and food production collapse simultaneously in less than fifty years. Pollution and population continue to grow beyond the point of economic collapse, beginning to decline only 1 to 2 generations later. Eventually an equilibrium may be reached, at lower levels of per capita food and industrial production than currently prevail.

Figure 2 depicts the consequences of continuing into the future the policy of uncontrolled growth that mankind has followed with some success over the last century. Is the result one to be welcomed? Hardly! The social implications of such a cataclysmic breakdown of the world economic system can scarcely be imagined. Life in a world whose population is halved by famine, disease, and other kinds of environmental stress will not be worth living.

But let us start with a more optimistic set of assumptions than was used in the "standard run": land productivity doubles; resource limitations are removed; and pollution per unit output is reduced to one fourth of present levels. The result is not very promising even under these more favorable circumstances, as shown in Figure 3. Food and industrial production rise rapidly over the next 40 years, bringing temporary prosperity. Eventually, however, pollution controls are overwhelmed by the vastly expanded waste generation rate. The resulting "pollution explosion" and concomitant collapse of food production cause an eventual population decline even more drastic than that of the "standard run".

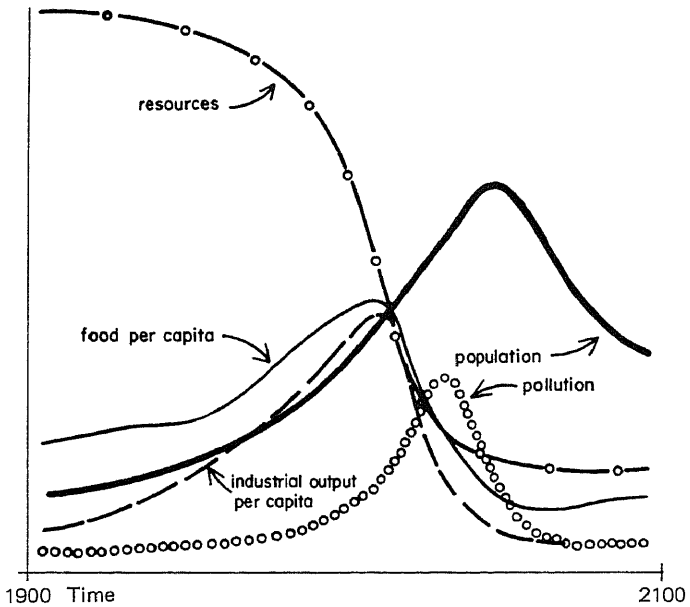
Is there any hope at all? The study group proposes that only a revolutionary change in present policies can assure an acceptable outcome. Population must be stabilized, resources recycled, and industrial output limited, as soon as possible. With energetic introduction of these measures, the stable conditions shown in Figure 4 could be reached within a generation – an equilibrium with per capita food and industrial production at three times present levels.

The same measures applied a generation later – in the year 2000 – would be ineffective. As shown in Figure 5, the declining resource base would lead to food shortages before the end of the 21st century. The end is not as cataclysmic as the "standard run", but neither is the ultimate decline of Figure 5 as welcome as the equilibrium offered by Figure 4.

The lesson should be clear. A sustained state of well-being on a global scale can be reached only by implementing far-reaching policy changes to limit population and industrial growth and control pollution virtually instantaneously.

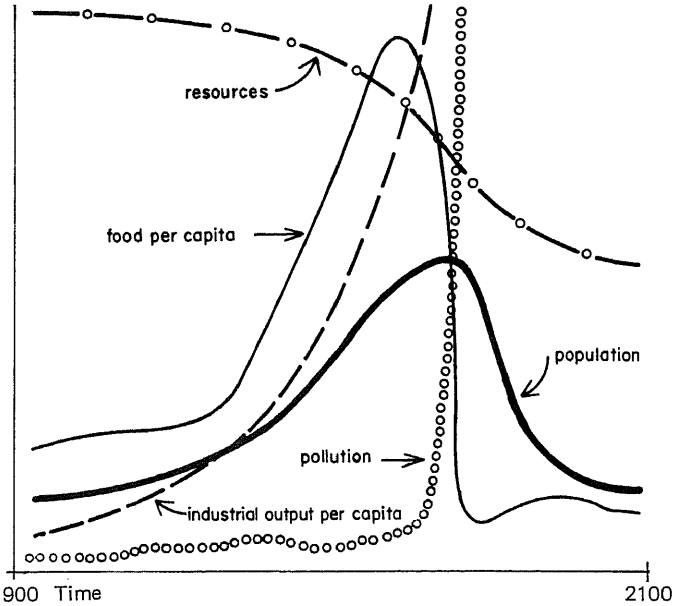
Many critics find the methodology of "The Limits to Growth" faulty. It is impossible to deal with the criticisms here; indeed many of them are substantial. Nonetheless, the model used by the MIT study group is presently our only choice if we wish to predict quantitatively the implications of present policies and growth trends. The goal of criticism should be to refine the model and expand it, especially in its social dimension.

Figure 2 **World model standard run**



Uncontrolled growth continued as until now leads to famine, disease and exhaustion of resources

Figure 3 **World model with "unlimited" resources, pollution controls, and increased agricultural productivity**



Granted that the resources are unlimited and food production doubled the "pollution explosion" leads to a collapse of food production after 40 years of prosperity

A Strategy for Survival

"The Limits to Growth" describes in very broad terms the changes needed to guarantee global economic and population equilibrium with a relatively high material standard of living. The project team did not attempt to develop a detailed plan for reaching that equilibrium state.

Indeed the action plans of various conservation and civic groups have bordered on the ludicrous. These efforts – typically published under a title something like "Forty Ways to Improve Your Environment" – make it clear that there is all too little the individual *can* do to influence his environment positively.

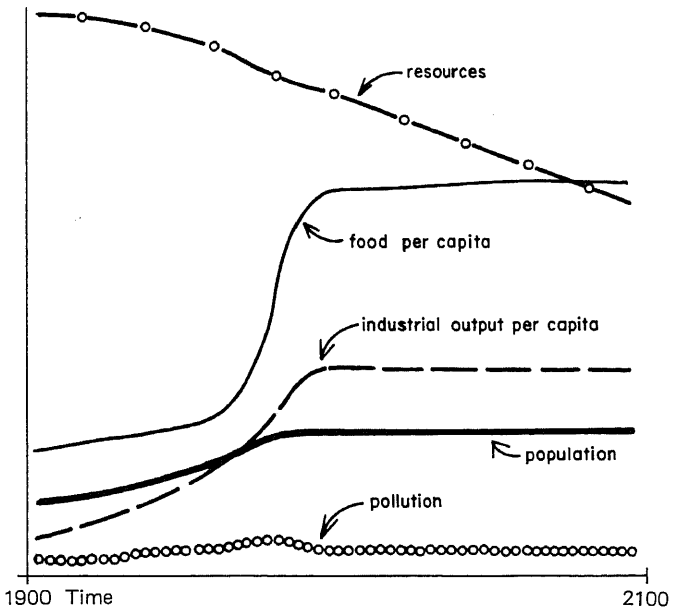
A group of British writers has attempted to fill the need for a comprehensive strategy in an article entitled "Blueprint for Survival" [3]. The authors attach the same sense of urgency concerning the limiting of population and industrial growth as underlies "The Limits to Growth", but have gone farther in outlining a strategy that they believe will permit survival. This strategy is outlined in Table 1.

To compile a "blueprint for survival" is an ambitious task. The authors of this document are to be commended for their courage in undertaking it.

Many of their exhortations will be criticized as unrealistic. Especially in the realm of economics, the strategy differs significantly from currently accepted theories that are based on optimization of "economic efficiency", of maximization of Gross National Product, and similar criteria. This conflict needs to be resolved, and the resolution will no doubt occupy a sizable portion of the brotherhood of economists for years to come. Economic theory is an imposing logical construct, but it is no more sturdy than its foundations in the theory of social behaviour. Rational social behaviour, in turn, ***must*** take into consideration the very real threat to mankind's survival.

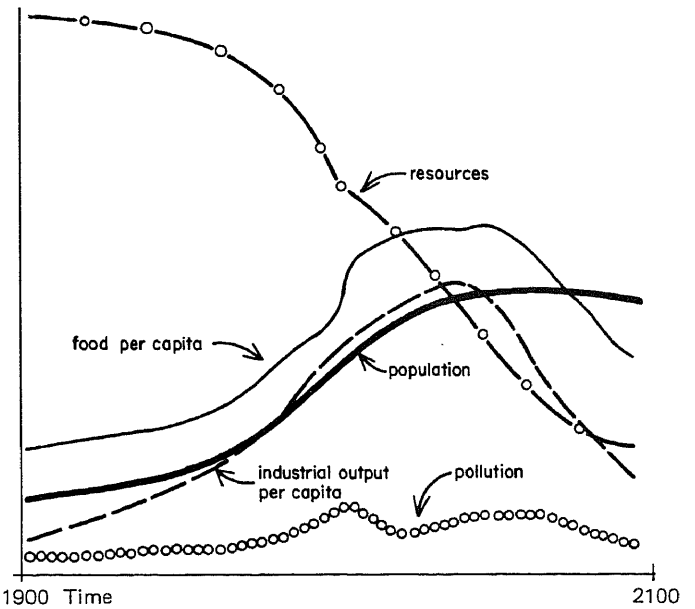
The "Blueprint for Survival" calls for decisive action to allow the continued existence of human civilization. The concept is in many respects incomplete and unconvincing. Many will criticize the proposals as radical. Indeed, the proposals are essentially revolutionary, calling as they do for immediate, fundamental changes in economics and social organization. Even with all of their defects, these proposals are worthy of careful and urgent consideration.

Figure 4 **Stabilized world model**



Stabilized population, recycled resources, and limited industrial output, could lead to stable conditions within one generation

Figure 5 **World model with stabilizing policies introduced in the year 2000**



If the stabilizing measures of fig. 4 are applied a generation later in the year 2000 the declining resource-base would lead to food shortage before the end of the 21st century

Summary

1. Waste management — except as part of a unified strategy of population control, resource management, and industrial/agricultural reorganization — is a delusion. It will only lead mankind into a still more insidious trap by removing the immediate pressure to regulate strictly population and industrial growth. The consequence of this "symptom treatment" approach to waste management is likely to be an even more serious threat to mankind's survival in one or two generations than exists at the present time.

2. There is an urgent need for concerted action — not just contemplation — in all aspects of the population/environment/resources problem. Deferring difficult changes will only amplify the resulting catastrophe.

3. The essential elements to a strategy for survival are:

   - Immediate population stabilization
   - Conversion to a recycle economy
   - Substitution of natural for synthetic products
   - Development of a new ethic emphasizing human relationships and quality of life as opposed to maximization of material possessions, and stressing equilibrium with the environment rather than its exploitation.

4. The social and political aspects of the survival problem badly need clarification. How can the mass of humanity, and particularly decision makers, be convinced that this is an imminent matter transcending their relatively petty differences? How can the developed nations be convinced to abandon some of their privileges in favor of the developing nations? How can the developing nations be convinced that the issue of mankind's survival is something more than a ruse to keep them economically subjugated? The proceedings of the recent U.N. Conference on Environment in Stockholm have shown that these questions — political though they may be — are of the highest priority. International cooperation is a prerequisite to mankind's survival.

1 Meadows, Donella H., Dennis L. Meadows, J. Randers, and W.W. Behrens III, "The Limits to Growth: A Report on the Club of Rome's Project on the Predicament of Mankind", Potomac Associates, Washington, D.C., 1972

2 Forrester, Jay W., "World Dynamics", Wright-Allen Press, Cambridge, Mass., 1971

3 Goldsmith, E., R. Allen, M. Allaby, J. Davoll, and S. Lawrence, "Blueprint for Survival", The Ecologist, 2 (1), 1 to 43 (January 1972)

Table 1

Strategy for Change
(Condensed from Reference 3)

A. Minimize disruption of ecological processes

1. Pollution control by elimination of ecologically harmful wastes as close as possible to the source — not by dilution or dispersal
2. Maximum recycling of materials
3. Substitution of natural processes and products for synthetic ones
4. Reduction of dependence on technology as a regulator of essential ecological cycles
5. Decrease in use of persistent pesticides; integrated control substituted for chemical control
6. Decrease in reliance on inorganic fertilizers by substituting organic manures. Adoption of diversified farming instead of monocultures
7. Better utilization of nutrients in domestic wastes; separation of domestic and industrial wastes to permit use of domestic wastes in agriculture
8. Creation of genetic banks to preserve diversity
9. Preservation of "nonproductive" wilderness areas and wetlands as genetic reserves and environmental buffers
10. Encouragement of public transport as an alternative to the private automobile

B. Conversion from a resource-consuming economy to a steady state economy

1. Measures to reduce the flow of raw materials: raw materials tax to penalize resource-intensive industries; graduated amortization tax (inversely proportional to product life) to penalize short-lived products
2. Government incentives to encourage recycling

C. Stabilizing the Population

1. Set population goals for nations or regions based on their population carrying capacity (food production potential)
2. End population growth by limiting the birth rate to equal the death rate
   - Mass communication to emphasize the urgency of the population problem and promote a socially responsible attitude toward child bearing
   - Free advice and services: contraception, abortion, sterilization
   - Research on demography and technical and cultural controls of population

D. Creating a new Social System

1. Decentralization of decision making to promote public participation in decisions on social issues. Strengthening of local government relative to central government
2. Decentralization of industrial power to make it more responsive to social needs; dispersal of industry from urban centers
3. Promotion of dispersed, autonomous, small communities
4. Deemphasis of material goods
5. Increased emphasis on social relationships and services (community feeling, global awareness)
6. Improved social accounting system to assure a more equitable distribution of environmental costs and to compensate for "externalities" (economic costs not reflected in private market prices) in socioeconomic decisions.

News from WHO

A WHO Expert Committee on Solid Wastes Disposal and Control met at EAWAG from 15 to 21 June 1971. A list of the Committee's participants and brief summary of its objectives are contained in the IRCWD-News, No. 2. The actual report of the WHO Expert Committee in "Technical Report Series, No. 484" and the April 1972 issue of the "WHO Chronicle" give further details and information on the Committee's deliberations.

The WHO Regional Office for Europe, Copenhagen, convened a Working Group 11 to 13 October 1972 for the purpose of studying, discussing and appraising a draft Model Code of Practice for Solid Waste Land Disposal in Europe. The Model Code is intended to provide governmental and other agencies, and particularly health administrations, with procedures and recommendations to assist them in the establishment and/or proper management of solid waste landfill. This activity is part of the long-term programme of the WHO Regional Office for Europe on environmental pollution control, and follows the recommendations of a Working Group on Development of Solid Waste Programme, convened at the Netherlands Institute of Public Health, Bilthoven, in May 1971. Observers were invited from the International Solid Wastes and Public Cleansing Association (ISWA), Organization for Economic Co-operation and Development (OECD), and the WHO International Reference Centre.

«IRCWD News»

The World Health Organization will convene a meeting of Directors of Institutions collaborating with the WHO International Reference Centre for Wastes Disposal from 13 to 17 November 1972. The meeting will take place at the Federal Institute for Water Resources and Water Pollution Control, Dubendorf, the host institute of the International Reference Centre. Its purpose is to review the progress of work of the International Reference Centre since its establishment in 1968, exchange research experience, formulate a long-term research and development programme, and identify specific areas where collaborative research could be intensified. The report of the meeting will be distributed to all Collaborating Institutions as soon as available.

Periscope

India

The following is a summary of the "Review of Work Done on Rural Latrines in India" published by the Indian Council of Medical Research in 1966.

Unsatisfactory disposal of human excreta is responsible for a large proportion of morbidity and mortality occurring in Indian villages. The provision of a sanitary latrine for every house is considered to be the first prerequisite for a solution of the problem.

At the time of independence, many types of latrines were available in India for adoption in the rural areas. Among these the borehole, pit or dug well, the hagevu, and the septic tank latrines were considered satisfactory in some respects and they were also used to a limited extent in different parts of the country. But none of these types, except the septic tank latrine which was beyond the means of the average villager, was considered entirely satisfactory and acceptable to all rural regions in the country. No systematic scientific studies were also attempted to define the defects in these latrines and to improve and make them more acceptable to the rural population. This state of affairs continued till about the year 1950.

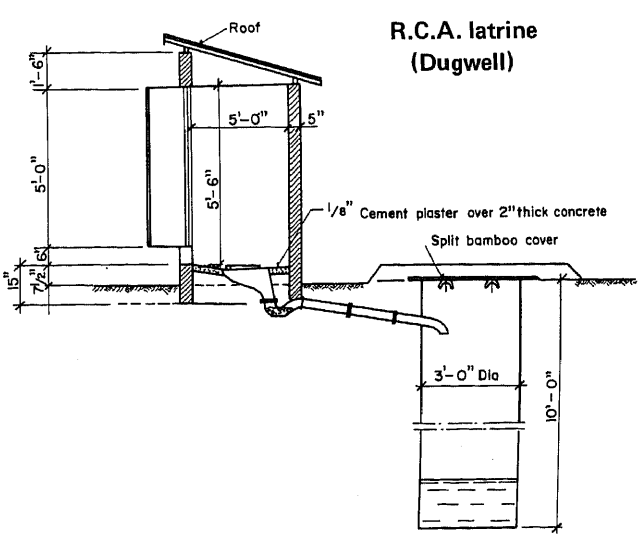
The PRAI at Lucknow were the first to undertake systematic studies to improve the design of the pan used in dugwell latrines and to make them more acceptable to the people. The Union Ministry of Health, in collaboration with The Ford Foundation, established the RCA Project in 1956 with three research centres at Poonamallee (Madras), Singur (West Bengal) and Najafgarh (Delhi) to carry out intensive study of the problem in all its aspects. The Indian Council of Medical Research also established, as part of their programme of research in Environmental Sanitation under the Second Five-Year Plan, research units in various states, to study the types of latrines that are best suited to these regions.

One of the important contributions arising out of the recent work is that a satisfactory design of the latrine, which can be adopted in all regions of the country has been worked out. The defects of earlier designs have been corrected and their best features have been incorporated in the new design. The new design, which is generally known as the RCA latrine, is a hand flush dugwell latrine provided with an improved water seal squatting plate and with the pit offset from the pan and trap. The RCA latrine has been tested in a number of field centres and found to be satisfactory both from hygienic point of view and acceptability by the local people. The design has been accepted by the Centre, and Stated Governments and local bodies for wide adoption in the country.

The use of RCA type latrines in rural areas also provides a means for the ultimate utilisation of the manurial value of human excreta without any health hazard. The recent work carried out on this aspect of the problem has shown that if the pit contents are allowed to compost with refuse or straw under an earth cover for a period of at least 3 months, the contents of the latrine can safely be used as manure. The material thus obtained is free from pathogenic organisms and can be handled easily and contains significant amounts of nitrogen and phosphorous in addition to humus which is a good soil conditioner.

One of the important considerations in the introduction of RCA type latrines in rural areas is the proximity of such latrines to rural wells and the chances of faecal pollution reaching the well through ground water. Detailed investigations have been carried out in the country on this aspect of the problem. The results of these investigations provide a proper scientific basis for judging the extent of pollution flow from RCA type of latrines installed under different soil conditions. On the basis of the available information, the safe distance between the latrine and well can be fixed for different soil conditions in the country.

The investigations so far carried out in the country also give information on the nature and content of the educational programme that has to be carried out among the rural population for promoting acceptance of the latrine by them. The improvement that this single measure will bring about in the mortality and morbidity statistics of bowel diseases, will be considerable.



R.C.A. latrine (Dugwell)

The two following reports concern the activities and programmes of the Central Public Health Engineering Research Institute (CPHERI) in Nagpur, India. Its publication, the "Technical Digest" gives further details and information on research projects carried out by this institute.

Textile Workers and Byssinosis Technical Digest, 1971, No 22

The CPHERI in Nagpur has undertaken a study on the incidence of byssinosis. With the object of ascertaining the existing concentrations of cotton dust in order to be able to prescribe safe levels, CPHERI also carried out a survey in some 9 textile units in Maharashtra State.

The study also included air borne dust and its protein content, nature of disease caused by byssinosis, influence of dust and protein concentrations in the air on incidence of byssinosis.

Pulp and Paper Mill Wastes Technical Digest, 1972, No 25

Pulp and paper industry is one of the largest water consuming industries in India. The amount of water required and wastewater discharged as well as its objectionable constituents such as colour, high suspended solids. BOD, COD, are indicated. Cost estimates are established for several sewage treatment processes. The difficulties of colour removal are discussed.

Perú

The following is an excerpt from "Stabilization Pond Installations in Latin America", drafted by A.P. Talboys of CEPIS, Lima, Perú, July 1971.

Stabilization ponds are geographically widespread in Latin America. Most countries of the region now have at least one pond in operational or experimental use. Recent progress has shown that the potential for more intensive use of stabilization ponds is considerable.

The number of ponds currently installed, under construction, or planned is as follows:

Country	Number of Pond Installations Reported
Brazil	30
Cuba	24
Argentina	23
Perú	21
México	14
Ecuador	11
Costa Rica	10
Chile	9
Colombia	7
Venezuela	7
El Salvador	5
Guatemala	4
Trinidad and Tobago	4
Nicaragua	3
Panama and Canal Zone	3
Barbados	2
Bolivia	1
Dominican Republic	1
Honduras	1
Uruguay	1
	181

The great majority of ponds designed and installed so far are for the handling of domestic-type waste waters. This exclusively holds true for Chile, Ecuador, México, Perú, and Venezuela. However, in Brazil and particularly in Central America (Costa Rica, El Salvador, Honduras, and Nicaragua) stabilization ponds are being used in significant number for the treatment of industrial and agricultural wastes. In two instances in Colombia, two in Trinidad and Tobago, and one in Brazil, combined sanitary and industrial wastes are being introduced into ponds. In Ecuador, El Salvador, and Venezuela single ponds predominate rather than multiple pond arrangements, whereas in Chile, Guatemala, México, and Perú the multiple pond set-up is favoured. In Brazil, the numbers of single and multiple pond configurations are about evenly divided.

Where single ponds are used, by far the greatest number operate as facultative ponds. Essentially all single ponds operating anaerobically are used for the treatment of industrial or agricultural wastes.

Multiple ponds have shown a great deal of flexibility and variability. Some systems operate entirely aerobically and some entirely facultatively, but most use an anaerobic-aerobic or anaerobic-facultative sequence with the pond in series. Entirely anaerobic operation is limited to industrial and agricultural waste applications. Ecuador is the only state to pratice the recirculation of effluent. However, a number of ponds were reported using artificial aeration (one each in Brazil, Colombia, Dominican Republic, and Uruguay) with three mechanically aerated pond systems under construction in Perú and one under consideration in Costa Rica. Aerated lagoons are also considered a possibility for Bogotá and Colombia.

A fair number of installations have been or are being operated on an experimental basis. These include four ponds in Colombia, three each in Brazil and Costa Rica, two each in Guatemala and El Salvador and one each in Chile and the Panama Canal Zone. Also Argentina and Perú have done some research on stabilization ponds, and Venezuela has a pilot plant installation under construction.

New publications

The Central Public Health Engineering Research Institute (CPHERI) in Nagpur, India, has sent us its new publication entitled "A Guide to Current Literature in Environmental Health Engineering and Science"(16th July 1972, Vol. 3, No. 6). It provides a list covering titles of papers published in the field of Public Health Engineering and related subjects.

Symposium

The Central Public Health Engineering Research Institute (CPHERI) in collaboration with the Indian Association for Water Pollution Control (IAWPC) has organised a symposium on "Environmental Pollution" to take place at CPHERI, Nagpur from 9th to 11th January, 1973. The following topics will be discussed: water pollution, water treatment, sewage treatment, industrial waste treatment, air pollution control, and solid waste disposal.

Abstracts

The subsequent abstracts have been taken from our documentation on solid wastes which contains at the present moment 1600 publications.

By January 1973 the thesaurus of terms in solid wastes will be made available to all Collaborating Institutions.

Harrington, M.J.: Ocean dumping: the oceans cry for help. Suffolk University Law Review, 1971, 5, No. 3, 878–898.

A serious problem of pollution has developed in the oceans because they serve as the final receptacle for much of the nation's wastes. Such wastes are either dumped directly into the ocean or are carried there by rivers. This article first describes the nature and effects of the ocean dumping of seven major pollutants: industrial wastes, solid wastes, sewage sludge, dredge spoils, explosive and chemical munitions, oil sludge, and chemical wastes. It next discusses the ineffectiveness of existing federal laws that might be applicable to the problem of ocean dumping. The abatement process under the Federal Water Pollution Control Act is too long and cumbersome. The Water Quality Improvement Act offers some help but has not yet been fully implemented. The federal government has been reluctant to prosecute under the Refuse Act. This article states that land-based waste disposal is one of the most feasible alternatives to ocean dumping. It is suggested that effective legislation against ocean dumping is needed. Encompassed by such legislation would be: (1) broad classification of the waters covered, (2) strong standards and prohibitions, (3) stringent enforcement, and (4) strong penalties for violations of the standards prescribed.

Anonymous: Ocean pollution and marine waste disposal Chemical Engineering, 1971, 78, No. 3, 60–67.

The final resting place of almost all pollutants is the world ocean. An overall examination of the various practices, problems, and constraints on marine disposal is presented. The bulk of marine pollution involves the edges of the sea, with some 39 estuarine systems identified by the Federal Government as having degraded water quality. Marine animals have not had to develop protective systems against intense environmental changes such as those caused by pollution, with the result that only a few fauna can survive. The marine pollutant categories discussed are: salinity; pH; temperature; dissolved oxygen; petroleum products; turbidity and colour; settleable solids; floating materials; tainting substances; nutrients; nuisance organisms; and toxic substances. A table is given showing industrial waste discharges, treated and untreated, in coastal states. Five recommendations and a table of factors are given to be considered in designing a disposal system to control process-plant pollution. Legal and legislative aspects of the control of ocean dumping are reviewed.

Scott, G.: Digestible plastic
Metaal Kunststof, 1970, 1, No. 4, 20–21.

Experts of environmental hygiene are becoming increasingly worried because of the way landscapes, c.q. nature in its entirety is being spoiled by non digestible plastics, mostly packing materials. Formerly, packing material was always biologically digestible, and many types of packaging were too expensive to be thrown out, e.g. glass. It has now become necessary that in the near future plastic materials will be produced that decompose after some time. The present article contains a review of the progress made in this field in the research center of the University of Aston in Birmingham (G.B.). It appears that decomposable plastic materials are definitely to be expected in the next few years. The technical consequences for the industries that use these materials are not great, but the selection of the right material will become even more complicated than it is, because of the increased number of factors that will have to be taken into account.

Howes, J.R.: The digestion of poultry feces under cages
Poultry Science, 1968, 47, 1682.

A series of small experiments were carried out under cages with and without concrete floors, using various absorbent substrates for poultry feces. After an initial buildup period, the feces and substrate was inoculated with aerobic bacteria and aerobic conditions maintained by disturbing the surface cake at intervals. These experiments led to a field trial without any absorbent substrate at a large cage operation in south Florida, which has now been in operation for 18 months. Odors and flies have been largely eliminated except in control plots and spraying for fly control greatly reduced. The bulk of the fecal pile was less than half the volume of the control plots due to stabilization of nitrogen and water losses. Feathers were digested if they were incorporated into the fecal pile and the resulting material was a homogeneous, odorless fertilizer which has been used in urban gardens and on golf greens.

Answers to Pollution Puzzle

▒	1 E	U	2 T	3 R	O	4 P	H	I	5 C	A	6 T	7 I	O	N	▒
8 M	▒	9 D	I	S	I	N	F	E	C	T	I	O	N	▒	10 M
I	11 A	▒	E	V	▒	A	▒	▒	I	▒	D	N	▒	12 D	I
13 C	N	14 D	▒	P	15 C	▒	16 O	17 B	▒	18 P	E	▒	19 T	I	N
20 R	A	I	21 N	▒	22 O	C	T	A	V	E	▒	23 P	O	S	E
24 O	L	G	A	▒	25 M	E	T	A	L	S	▒	26 L	I	A	R
27 O	P	E	R	▒	B	▒	O	L	▒	T	▒	28 A	L	G	A
R	H	▒	29 R	O	U	E	▒	▒	30 S	I	G	N	▒	R	L
G	A	▒	31 A	N	S	O	▒	▒	32 I	C	R	K	▒	E	I
33 A	B	34 E	T	▒	T	▒	35 A	36 R	▒	I	▒	37 T	38 O	E	S
39 N	E	R	E	▒	40 I	S	L	A	N	D	▒	41 O	L	M	A
42 I	T	I	S	▒	43 O	C	T	A	N	E	▒	44 N	I	E	T
45 S	I	C	▒	46 D	N	▒	O	B	▒	S	47 G	▒	48 O	N	I
M	C	▒	49 A	O	▒	50 T	▒	▒	51 T	▒	R	52 F	▒	T	O
S	▒	53 I	N	C	I	N	E	R	A	T	I	O	N	▒	N
▒	54 W	A	T	E	R	P	O	L	L	U	T	I	O	N	▒

Puzzle Editor, B. Krummet

S. Peter, Editor
"IRCWD News"
Swiss Federal Institute of Water Resources and Water
Pollution Control (EAWAG)
Ueberlandstrasse 133, CH-8600 Duebendorf, Switzerland