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THE RELATIONSHIP BETWEEN WATER-RELATED DISEASE AND WATER QUALITY WITH PARTICULAR REFERENCE TO URBAN WATER SUPPLY IN A DEVELOPING COUNTRY

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1. ABSTRACT

The problems of urban water supply and water related disease in the Americas are examined in the context of population growth and geographical features. The debate concerning the transmission of potentially water-borne pathogens is discussed. The factors affecting the quality of water supply services in a large metropolitan area (Lima) are described and the epidemiological characteristics of water-related disease summarised and compared with data from Africa (Lesotho).
A water quality additive index is proposed in order to identify the level of risk for each metropolitan district. This incorporates the presence of faecal coliforms and the absence of chlorine residual. A water-related disease product index (DPI) is also proposed which incorporates the incidence of typhoid, hepatitis and diarrhoea. The indices were matched for all districts, where adequate data were available, and a strong correlation was noted. The water quality index was divided into categories (A,B,C) and it was observed that these were generally dependent upon the water supply service levels. It is concluded that disinfection control is grossly deficient in most developing countries but essential for the control of water-borne disease.

1.1 KEYWORDS

Water-related disease transmission; disease product index (DPI); typhoid; hepatitis; diarrhoea; water quality index; faecal coliforms; chlorine residual.

2. THE PROBLEM OF WATER SUPPLY AND POPULATION GROWTH

The Decade Dossier for the International Drinking Water Supply and Sanitation Decade suggested that 40% of the population in developing countries had access to an adequate and safe water supply. However the efforts to improve this level of coverage during the last two decades are being overwhelmed in the urban sector by rapid population growth and poor maintenance. It has been estimated that about 100 million more people drink unsafe water now than in 1975 (World Water, 1981). In the low income developing countries population growth proceeded at an annual rate of 1.2 per centduring the 1970's while that for the middle income group was 2.4 per cent (World Development Report, 1982).

2.1 The urban sector

Many of the problems of urbanisation are typified by the South American region where overall population growth is proceeding at 2.4 per cent. However the growth rate in the urban population is 3.8 per cent (Inter-American Development Bank Report, 1982). Thus whilst the rural population of the region appears to be stabilising at around 116 million the urban sector is under increasing pressure to absorb almost all of the demographic growth.

There are 286 cities in Central and South America which have more than 100,000 inhabitants each. This accounts for 168 million (45 percent) of the population of 376 million in the region. Inevitably the rapid growth of the urban population has aggravated environmental and associated health problems. In particular water resources are becoming scarcer whilst demand is increasing. Traditional sources are becoming contaminated and new sources more costly to develop. Water supply is therefore not keeping pace with slum growth. Industrial wastewater and sewage are inadequately treated, or more usually not treated at all. There is little control of discharge and convenience has been the primary consideration. A quarter of the major cities are located in coastal and estuarine areas (Figure 1) and coastal outfalls have been an obvious means of wastewater disposal (Bartone and Salas, 1983). More seriously, in the arid zones, sewage reuse for irrigation has increased dramatically with little regulation or regard for the risk of crop contamination by pathogens and parasites.

The geographical distribution of these major urban centres (Figure 1) is associated with several features which contribute to the public health engineering problems. The great majority of the population inhabit tropical zones of high humidity which favour the transfer and growth of bacterial agents of diarrhoeal disease on moist foodstuffs. This is particularly true for much of continental Central America and tropical South America where the death rate in infancy and early childhood are highest (Table 1). The enteric and diarrhoeal disease group constitute the most severe health problem in the region and throughout the Third World. PAHO/WHO data (Table 2) show that this group continues to be the number one cause of mortality amongst small children who, according to Canadian data, consume more drinking water per kilogram of body weight than adults.

To what extent diarrhoeal disease and other enteric infections are directly attributable to water quality we shall attempt to assess with reference to available data. However from the above it is clear that the availability of reliable microbiological, and in particular faecal indicator data, assumes paramount importance in assessing the health risks attributed to water supplies.

2.2 Water supply and water related disease

The European and North American experience has demonstrated how a range of developments in social and allopathic medicine, public health engineering and a rise in general living standards have all but eliminated the major communicable disease problems of the nineteenth century. Today we are striving to solve the same basic problems in developing countries where the population is orders of magnitude greater and financial resources increasingly scarce. The temptation is therefore to attempt to find low cost intervention strategies or single interventions which have maximum health impact. Urban water supply however cannot be low cost but is so vital to basic living requirements and hygiene that it is expected, on its own, to have a profound influence on the incidence of a range of infectious diseases.

TABLE 1
INFANT MORTALITY DATA FOR THE AMERICAS, 1979*

Subregion	Death rate per thousand		Percentage of all deaths	
	Under 1 year	1-4 years	Under 1 year	1-4 years
Northern America	12.9	0.7	2.4	0.4
Caribbean	20.5	0.7	10.5	3.0
Continental Middle America	50.9	10.4	28.4	15.4
Temperate South America	32.5	1.5	11.5	1.9
Tropical South America	36.6	4.2	24.0	10.5

* PAHO "Health Conditions in the Americas, 1977-1980". PAHO Scientific Publication No. 427, Washington, D.C. (1982).

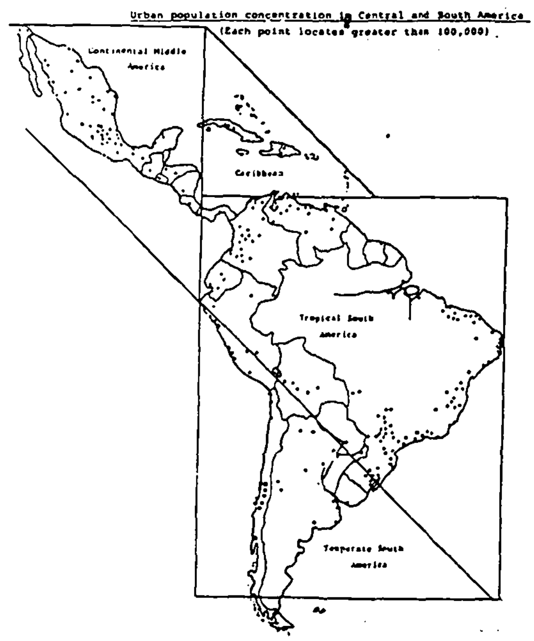

Fig. 1. Urban population concentration in Central & S.America

The importance of the enteric and diarrhoeal disease group has already been referred to and their association with water is sufficient for them to be classified as water-borne and water-washed (Feachem, 1977). However, some studies including that of Feachem et al., (1978) have shown a poor or negative correlation between diarrhoeal disease incidence and water supply improvement. In most cases other factors may have obviated the benefit of good water quality and in the case of some rural investigations the population under study may have been statistically insufficient. Thus for example in Egypt, the ratio of handpumps to population served was unfavourable (Weir et al., 1977). Rahman (1979) however demonstrated the importance of adequacy of supply, by showing an inverse relationship between volume of supply and shigellosis attack rates. There is a consensus that cholera transmission, in riverine and deltaic regions, is primarily water borne (Spira et al., 1980; Curlin et al., 1977; Hughes et al., 1977), but an understanding of the principal transmission routes of some of the more recently identified aetiological agents of diarrhoeal disease such as enterotoxigenic E. coli, rotaviruses and Norwalk virus are at present lacking.

A fundamental difference exists between the viruses and bacteria capable of infecting the mammalian intestine in as much as the latter group are capable of multiplying in moist food stuffs. The bacteria can therefore increase their inoculum potential outside the human host and the food-borne transmission route therefore becomes a most effective mechanism for this group of organisms. In contrast water and poor hygiene (hands) are relatively ineffective means of transmission of large inocula. Thus water, whilst serving as a highly effective dispersant for the spread of an inoculum throughout the environment, paradoxically also acts as an excellent diluent which reduces inoculum potential. Similarly inocula on hands are rapidly reduced in a dry environment, but effectively dispersed and sometimes directly transmitted (parent to child) or indirectly via food. Thus the three vehicles are so intimately associated, as indicated in Figure 5, that it is often impossible to extricate the impact of water quality alone.

TABLE 2

NUMBER OF DEATHS FROM DIARRHOEAL DISEASES IN CHILDREN UNDER 5 YEARS OF AGE, WITH RATES PER 100,000 POPULATION, AND RANK ORDER AS LEADING CAUSE DEATH, SELECTED COUNTRIES: 1970 AND 1979.

Country	1970						1979					
	Under 1 year			1-4 years			Under 1 year			1-4 years		
	Number	Rate (a)	Rank order	Number	Rate	Rank order	Number	Rate (a)	Rank order	Number	Rate	Rank order
Argentina	4,561	880.5	3	722	38.5	3	2,641	463.3	2	420	20.0	2
Belize	39	823.6	1	15	86.7	1	45	762.7	1	9	41.2	1
Chile	3,853	1,418.1	3	422	46.7	3	705	264.9	3	85	8.6	3
Costa Rica	845	1,509.5	1	271	108.1	1	136	195.3	4	24	11.2	4
Cuba	1,313	564.7	4	82	8.6	4	237	122.7	4	41	4.3	5
Dominica	25	984.6	1	13	127.1	1	5	178.5	1	3	25.4	1
Dominican Republic	1,642	1,177.9	1	612	111.1	1	949	538.8	1	321	46.1	1
Ecuador	2,382	968.9	1	1,691	194.4	1	3,667	1,144.1	1	2,605	231.0	1
Guatemala	3,643	1,817.8	1	5,749	807.6	1	3,934	1,311.3	1	3,864	424.1	1
Honduras	880	792.7	1	1,166	299.5	1	926	873.5	1	624	11.4	1
Martinique	63	598.4	1	20	47.9	1	39	390.0	3	2	4.7	3
Mexico	37,197	1,744.2	1	20,464	274.0	1	30,805	1,258.8	1	11,393	127.2	1
Panama	275	588.6	2	209	112.5	2	158	305.9	1	158	77.2	1
Peru	5,501	1,802.1	3	3,798	209.1	3	4,872	751.8	1	3,058	144.6	1
St. Vincent	47	588.6	2	16	118.6	2	23	403.5	1	8	45.9	1
Trinidad and Tobago	169	710.0	2	28	25.5	2	159	676.0	1	43	43.1	1
Uruguay	254	479.2	-	14	6.4	-	284	521.1	5	15	7.1	5
Venezuela	1,673	874.7	1	1,373	94.2	1	2,836	600.8	2	634	38.2	2

(a) Per 100,000 live births.

Source: PAN AMERICAN HEALTH ORGANIZATION. Health conditions in the Americas 1977-1980. Scientific Publication No. 427. Washington, D.C., 1982.

The major pitfalls in measuring the impact of water supply and sanitation investments by the use of epidemiological data on diarrhoeal disease have been summarised by Blum and Feachem (1983). In spite of the methodological problems which they identify, the magnitude of the disease problem is such that we are bound to scrutinise the data for benefits wherever information becomes available. According to Walsh and Warren (1979) there are of the order of 5,000 million water borne infections resulting in at least 10 million deaths each year in Africa, Asia and Latin America. We therefore propose to examine the relevant health data for a large South American metropolitan area in the context of its water supply and water quality problems.

2.2.1 Existing problems of water supply and water quality in Lima

It is estimated that 65% of the inhabitants of Lima are served by sewerage and piped water. The water supply is derived from two principal sources. The whole of central Lima and areas peripheral to the city centre are supplied by the River Rimac, a grossly polluted Andean source, which is contaminated by excreta from towns and villages upstream as well as by mining wastes and annual land slides in the mountains. Its treatment plant has therefore to cope with both high microbial contamination and turbidity levels which exceed 10,000 JTU in the December to April rainy season in the Andes. The other major source of supply is deep bore holes, of which there are in excess of 240 in the metropolitan area, although the highest proportion are located in the suburbs. The water supply system is complicated by the fact that major areas on the north and south sides of the city have a mixed supply from both deep wells and the treatment plant. From the point of view of quality and quantity the city faces critical problems arising from the following causes:

a) The population of Lima is currently growing at an estimated 300 per day, largely by invasion of desertic areas on the fringe of the city.

b) There is negligible rainfall throughout the year and therefore no effective recharge of the groundwater other than in the zone adjacent to the river.

c) The groundwater table is (as a consequence of b) falling at an alarming rate - several meters per year. This is further aggravated by abstraction for agricultural purposes in the three river valleys of the Lima district. In other parts of Peru irrigation water frequently takes precedence over domestic supplies and in periods of water shortage sharing practices are highly organised. In the metropolitan area however it is clear that where there is competitiion between agricultutal and domestic use, agriculture is fast disappearing.

d) The depleted groundwater table is therefore at greater risk of contamination as the process of draw down continues, particularly in the area of the wells. Chlorination is essential, but rarely practiced.

e) An increasing demand is being imposed on the River Rimac and it has been predicted that its supply capacity will be exceeded before 1990. This may be partly offset by the Mantaro valley transfer scheme which proposed to extend the diversion of water from the Amazonian water shed to the Rimac. However it may already be too late to avoid a major crisis in supplying Lima with this water which is in any case of doubtful quality with respect to heavy metals.

f) Major sectors of the urban slums, amounting to almost one quarter of the total population of Lima, already have to be supplied by tanker to open household containers. These are inevitably subjected to gross microbial contamination.

g) Each year between December and March the Lima treatment plant is paralysed for a number of days by untreatable water due to excessively high turbidities. This results in some sectors of the metropolitan area being starved of water and a consequent high risk of contamination in an otherwise direct pressure system. In many districts there are no roof storage cisterns and in a large area of the central city district pressure is inadequate to raise water to the level of the first floor.

In the period 1971 to 1982 the population of Lima nearly doubled, from 2.7 million to almost 5 million when the port of Callao is included. This growth was accompanied by urban sprawl as the area of the capital increased from 255 km^2 to 458 km^2 at the expense of 200 km^2 of agricultural land. All of the foregoing point to a crisis in water supply and it is therefore vital that the capacity of the Lima water authority (SEDAPAL) should be developing effectively at this time. The master plan for water supply to Lima has proposed an emergency plan for groundwater exploitation which has recently been financed. This is intended to enable a postponement of the Mantaro Valley transfer scheme, but it will be demonstrated in the discussion that follows that the groundwater sources themselves are suspect.

2.2.2 The relationship between water quality and health data in Lima - a case study

Diarrhoeal disease incidence in Lima and contiguous Callao has an age distribution which is typical of that found in most developing countries. Figure 4 demonstrates the very high incidence of infection in the first year of life. In many of the urban slum districts it has been reported that six to eight episodes of diarrhoea are the norm in the first year of life. Figure 4 clearly emphasises the major risk of exposure during the first five years.

When we examine the seasonality of diarrhoeal disease and typhoid one is impressed by their peak coincidence with temperature in the first quarter of the year and their progressive reduction through the cooler months. This is only partially complemented by the data for hepatitis which nonetheless exhibit a similar trough in the coolest months (Figure 2).

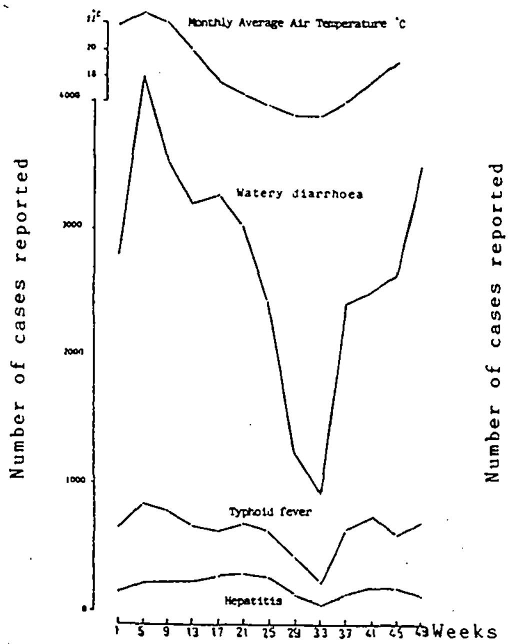

Fig.2.Seasonality of diarrhoea, typhoid and hepatitis in Lima.

Fig.3.Seasonality of diarrhoea in Roma, Lesotho.

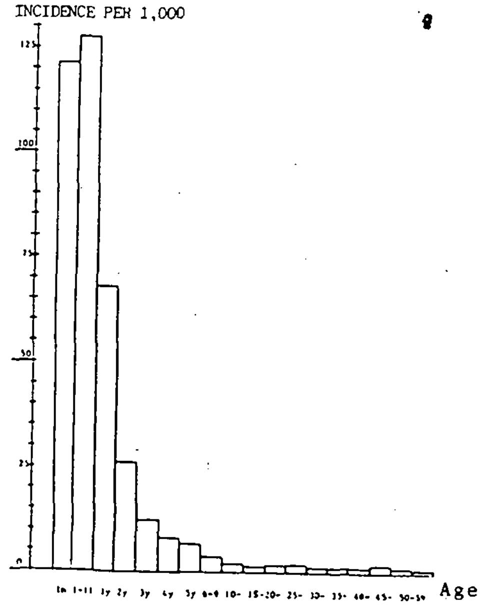

Fig.4.Diarrhoeal disease incidence by age in Lima and Callao (Peru).

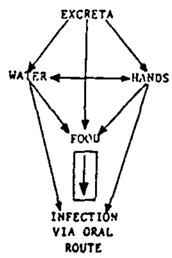

Fig.5.Faecal-oral transmission routes of bacterial pathogens

It is of interest to compare this with diarrhoeal disease reportings at rural hospitals in Lesotho in southern Africa (Figure 3). Although the temperature range is somewhat wider the coincidence of peaks and troughs is similar through the year. However in Lesotho the peaks also correspond to the wet season whereas Lima experiences almost no rainfall throughout the year. We will examine the Lesotho case study more closely under the final section since some water quality data are available for assessing the influence of water supplies in that location. However systematic water quality data have become available since 1981 for almost all of the metropolitan districts of Lima which may therefore be compared with the incidence and distribution of diarrhoeal disease, typhoid and hepatitis in the districts in the same year. Although it must be accepted that disease diagnosis and reporting in some districts is poorly developed nonetheless a population of five million is statistically more than adequate to attempt correlations with water quality data.

On the water quality side we consider that two critical parameters are essential to judge the hygienic quality of water. These are faecal coliform count (F.C./100 ml) and presence or absence of chlorine residual throughout a particular supply zone. We therefore propose a water quality additive index which is a composite of both parameters. We define this WATER QUALITY ADDITIVE INDEX as:

"Percentage of F.C./100 ml positive results + percentage of chlorine residual negative results".

This produces an index range of zero to 200; zero thus representing highest quality water and 200 highest risk supply districts. Thus a district with greater than 95% of all samples throughout the year having no faecal coliforms and 100% chlorinated will have a water quality index of less than five and we will call this category A water. However we will only permit indices to be calculated and included in the general analysis if there are 10 or more sampling occasions throughout the year.

We have resisted the temptation to further complicate the water quality index at this stage e.g. by weighting the level of faecal contamination in the calculation, since broad categories are already clear.

Category	Water Quality Index range	
A	0 - 4.9	First class quality and service throughout the year.
B	5 - 49.9	Spasmodically unchlorinated and frequently contaminated.
C	50 - 200	Normally untreated and regularly contaminated. Spasmodic interruptions in supply. Well supplies and tankered water.

Since diarrhoeal disease, typhoid and hepatitis may all be transmitted via the water route we have elected to combine all three into an index which we shall call the DISEASE PRODUCT INDEX (DPI). This is calculated from the incidence per 1,000 of each disease thus:

Diarrhoea x Typhoid x *Hepatitis* = D.P.I. We have chosen to use a product rather than an additive index to avoid a single disease incident being unfairly weighted whilst increasing the range and hence the sensitivity of the DPI scale.

The 1981 disease incidence data for Lima are presented alongside the corresponding water quality data for each district in Table 3. The water quality additive index is plotted against the DPI in Figure 6. The correlation coefficient is impressive, at 0.779, but more importantly three categories of water supply quality and service level can be *readily distinguished* which correlate well with the various levels of disease product index.

Category A

In spite of grossly contaminated raw water the Atarjea treatment plant supplies water of a *consistently* high quality to six central metropolitan districts of Lima throughout most of the year. The supply is properly chlorinated and these districts fulfil the WHO guideline for 95% of samples throughout the year being negative with respect to coliform contamination. Significantly none of the six districts have been found to be deficient in chlorine, and five of them are in the low water-borne (low disease product index) category. Equally significantly the *top three* represent the top residential areas of the city and the lowest DPI. This points up the additional significance of the socioeconomic variables including wealth, hygiene and nutrition although a separate analysis of these has been excluded.

Category B

Also within the central metropolitan area there are districts served by both treatment plant and supplemented by well supplies. It is important to note that those areas are all at times deficient in either bacteriological quality or chlorination or both. There are undoubtedly subdistricts in which the distribution system is spasmodically subject to gross contamination and without the safeguard of residual chlorine an ever present risk of water borne infection. This is indicated by the elevated DPI in the range 5-25 and correlates well with a water quality index in the range 5-50. Nine districts fall into this category, although two are suburban rather than central and include low pressure areas to which water has to be tankered.

Category C

The worst category is exclusively suburban and supplied either by wells or by tankering. The risks of tankering to unprotected storage cylinders are obvious, but it is noteworthy that five of eight districts in this group are continuously supplied by piped well supplies. These are uniformly unchlorinated and subject to an ever present risk of pollution particularly under the drought conditions of Lima. It is also important to note in this category that the district of La Molina is predominantly populated by the upper socioeconomic groups in which hygiene and nutritional factors should therefore play a lesser role.

Only three districts have DPI values which fall below the category predicted by the water quality index. Two of these are believed to be deficient in disease reporting procedures, the third requires more advanced socioeconomic analysis.

TABLE 3

Water quality and water-related disease incidence data for districts of Lima (1981-1982)

DISTRICT	WATER QUALITY			DISEASE INCIDENCE/1,000			Disease Product Index (DPI)
	Faecal coliform (% + ve)	Chlorine Application (% - ve)	Additive Index	Diarrhoea	Typhoid	Hepatitis	
1. Miraflores	1.3	0	1.3	5.28	0.37	0.164	0.32
2. San Isidro	4.1	0	4.1	1.04	0.70	0.365	0.26
3. Lince	0	0	0	6.07	0.75	0.211	0.96
4. San Luis	0	0	0	9.43	1.31	0.192	2.37
5. La Victoria	3.3	0	3.3	5.12	1.07	0.572	3.13
6. Jesús María	4.5	0	4.5	5.65	1.29	0.986	7.19
7. Callao	10	10	20	4.63	1.40	0.420	2.72
8. Rímac	3.5	20	23.5	7.16	1.64	0.550	6.81
9. Breña	12.1	0	12.1	2.67	2.41	0.943	6.06
10. Surquillo	6.4	20	26.4	12.48	1.89	0.306	7.22
11. Pueblo Libre	5.0	20	25.0	9.31	1.67	0.607	9.44
12. Lima - Central	8.1	20	28.1	11.61	1.88	1.137	24.82
13. Santiago de Surco	4.4	20	24.4	14.23	1.81	0.300	7.73
14. San Juan	9.1	10	19.1	12.81	1.76	0.507	11.43
15. Villa María	4.5	10	14.5	10.75	3.44	0.545	20.15
16. Chorrillos	21.9	20	42	10.82	1.17	0.522	6.61
17. San Miguel	16.0	50	66	3.87	1.06	0.373	1.53
18. Comas	16.2	70	86.2	5.56	2.49	0.378	5.23
19. San Martín	6.0	80	86.0	7.62	1.68	0.704	9.01
20. Lurigancho	14.8	80	94.8	13.66	5.48	1.56	116.77
21. Independencia	50	95	145.0	9.92	2.58	0.646	16.53
22. Puente Piedra	22.5	100	122.5	14.8	3.10	0.825	37.85
23. La Molina	21.4	100	121.4	29.13	2.11	0.887	54.52
24. Pachacamac	54	100	154	23.60	1.77	1.622	67.75
25. Lurín	100	100	200	32.95	6.06	0.981	195.88
26. Pucusana	100	100	200	99.42	6.09	1.462	885.19

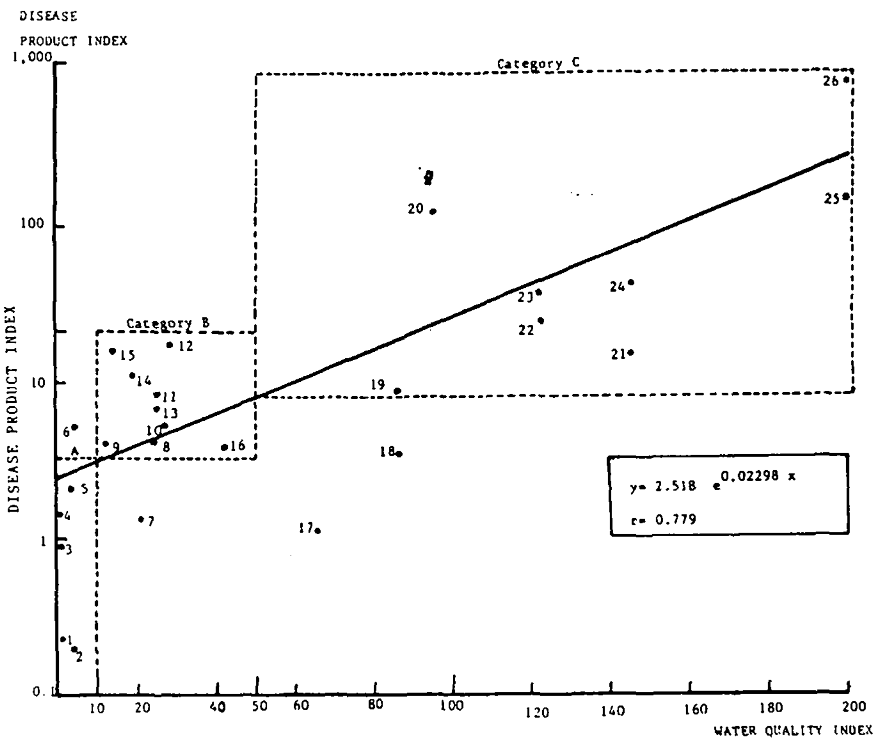

Fig. 6. Relationship between water related disease indices and water quality for districts of Lima - Peru (1981-82).

3. DISCUSSION

Water quality and water-related disease

Feachem et al (1978) have examined diarrhoeal and typhoid reporting to hospitals in Lesotho in areas where water supply has been improved and others which have not. They concluded that where water quality was the only parameter improved and where there was neither any increase in the volume of water used nor any change in domestic and personal hygiene, then there was no detectable change in the incidence of water-related diseases in study villages. Furthermore they concluded that the spatial and temporal distribution of typhoid reportings did not support a water-borne transmission hypothesis. They also believed that the wet season peaks of diarrhoeal disease were not associated with poor water quality. They suggested that the survival of pathogens in the moist, warm conditions of the wet season in Lesotho may be significantly better than in the dry, cold conditions of the winter, and that this might be an important factor in food contamination and hence food-borne transmission. However, they also reported that 69 percent of water sources tested showed bacterial contamination to have overall mean concentrations 5.4 times higher in the wet than in the dry season. Although they rejected a water-borne explanation of both typhoid and diarrhoea they were careful to point out that the data at their disposal were insufficient to make other than informed guesses.

The Lesotho study raises important questions about the level of improvement of water quantity and quality which is necessary to eliminate water-borne infections arising from rural supply systems. Whilst the argument that quality is less important than quantity is valid when there is not enough water available in the home for basic hygiene purposes, the question which is still begging is as follows. Given sufficient water for domestic purposes (say 50 litres per capita per day) what level of faecal contamination does not pose a risk of water-borne infection to the community? The WHO Guidelines (1984) recommendation for large supplies is unequivocal, zero coliforms and *E. coli*, and not less than 95% of samples should be negative throughout the year. In practice however, this level of control is rarely achieved, even in some of the advanced countries' urban water supply systems. The debate then commences as to whether what were previously described as standards should be relaxed, at least for rural supplies.

The Lesotho data demonstrate that in the rural environment simple improvement projects such as the protection of spring water can readily reduce the level of faecal coliform contamination by almost two orders of magnitude, from say 1000 down to 20 faecal coliforms/100 ml. But these values represent average reductions and there is no guarantee that any source will remain with low levels of contamination throughout the year, and since there is no barrier against contamination other than source protection their safety is highly suspect. Feachem, et al (1978) argue that the improved supplies are much better than unimproved supplies and that since the diarrhoeal disease and typhoid do not appear to be primarily water-borne, the costs and maintenance problems of treatment under Lesotho village conditions are unjustified. The implication seems to be that the regular occurrence of low levels of faecal coliforms is acceptable. It is certainly inevitable unless there is an additional measure of protection such as routine chlorination to provide a free residual of hypochlorous acid in the distribution system. Feachem et al condone the Lesotho village water supply policy which is not to undertake disinfection, because of the problems of operation and maintenance. This is not an argument with which we concur. Whilst it must be admitted that the training needs for operating and maintaining water supplies and sanitation facilities in the developing countries present the greatest difficulty it is generally agreed that this sector should have a high priority. In the case of disinfection there is a strong case for introducing this into rural water supply practice. Not only does a free residual of chlorine provide protection against the introduction of many pathogens in a distribution system; it may also persist long enough in a bucket of water drawn from a standpipe system to control post collection contamination. For example, an initial free residual of 0.6 mg per litre was reduced by 66 per cent to a still useful 0.2 mg per litre after twelve hours at 21°C. This is particularly important in view of the commonly reported observation that an initial level of 0-10 faecal coliforms (F.C.) per 100 ml standpipe sample is converted to 100-500 F.C. per 100 ml in unchlorinated water, through careless transport, storage and use.

There have been very few controlled experiments on the reduction of the incidence of infant and early childhood diarrhoea resulting from chlorinated versus non chlorinated water. However, a recent unpublished report from West Bengal (Institute of Child Health, 1982) examined the influence of regular cleaning and refilling of household water pots with chlorinated water. A control group received a placebo of distilled water which was unchlorinated. The reduction of childhood diarrhoea in the group receiving chlorine was 75 per cent greater than in the placebo group. If true, this provides as strong a case for promoting chlorination as for the global oral rehydration programme. In the meantime less stringent guidelines for rural water supply quality have been proposed. Volume 1 of the 1984 WHO Guidelines states that for unpiped supplies:

> "the objective should be to reduce the coliform count to less than 10/100 ml, but more importantly to ensure the absence of faecal coliform organisms ... Greater use should be made of protected groundwater sources and rainwater catchment, as these are more likely to meet the guidelines for potable water quality."

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