A SURVEY OF THE SUPPLY AND BACTERIOLOGIC QUALITY OF DRINKING WATER AND SANITATION IN JAKARTA, INDONESIA

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Abstract. We assessed the water supply, water quality and human waste disposal and their association with diarrheal illness in Jatinegara, East-Jakarta, where part of the area has been involved in the *Kampung* Improvement Program (KIP). Three hundred seventy-eight households, randomly selected in the study area, were visited and questioned about water source, sanitation and diarrheal illness during the previous 3 months. Microbiological quality of drinking water was assessed. The water sources were boreholes (243; 64%), the water mains (77; 20%), bottled water (45; 12%), and vendors or dug wells (243; 4%). Fecal coliforms were isolated in 56% of the samples [median 23 (IQR 6-240) /100 ml in the contaminated samples]. Only 2 (3%) of the water mains' samples contained >100 fecal coliforms/100 ml, compared to 57 (24%) groundwater samples. Most residents used private toilets with drainage into on-site septic tanks, yet in over one quarter of households human excreta was disposed of into rivers or gutters. KIP areas lagged behind in environmental hygiene. Diarrheal episodes, reported in one third of the households, were significantly associated with water contaminated with >100 fecal coliforms/100 ml [OR 2.4 (95%CI: 1.4-4.2)], but no association with water source or environmental contamination was found. Significantly, all individuals reported boiling water before consumption.

INTRODUCTION

The second greatest cause of Disability-Adjusted Life Years worldwide is the combination of poor water supply, poor sanitation and lack of personal hygiene (Murray and Lopez, 1997). A substantial proportion of the population in developing countries lacks access to high quality drinking water (WHO, 2000). Health benefits that can be derived from improved water supply not only depends on improvement in water quality, but sanitation as well (VanDerslice and Briscoe, 1995; Esrey, 1996). Improvements in water quality alone have been shown to reduce morbidity rates of diarrheal illness by 16%. However, improvements in both water quality and availability resulted in a reduction in morbidity rates of 37% (Esrey *et al*, 1991). Inadequate water and sanitation have adversely affected the nutritional status of children, but a better water source alone did not give the full health benefits in Peru (Checkley *et al*, 2004). Next to improvements in the "hardware" components of water supply and sanitation (the physical infrastructure), "software" interventions are essential to improving health outcomes (Varley *et al*, 1998). The latter refers to the responsibility of the health sector in water and sanitation interventions: the transfer of knowledge and initiatives to induce changes in behavior (hygiene education, social marketing, surveillance and monitoring).

The interaction of water supply, water qual-

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ity and sanitation has not been evaluated in Jakarta, Indonesia, where waterborne diseases are endemic (Oyofo *et al*, 2002; Subekti *et al*, 2002). We compared the bacteriologic quality of drinking water from different water sources and the sanitary conditions in an urban environment in which some slum-areas had been under going *Kampung* (slum) improvement projects (KIP). Our data should help determine health risks for citizens in Jakarta and to determine which interventions are required to reduce these health risks.

MATERIALS AND METHODS

Study area and population

Jakarta, Indonesia, has an officially registered population of more than 9 million inhabitants, of which 40-50% are slum dwellers. The city is located on the shores of the Java Sea. Forty percent of its surface are below sea-level. The rainy season lasts from December to April and the dry season from May to November.

In 1998, the municipal water supply in Jakarta became a joint-venture of the city-owned utility PAM Jaya and two foreign partners, Thames and ONDEO, each providing water to about 300,000 households in North-East and West-Central Jakarta, respectively. At the initiation of the cooperation, 43% of Jakarta's population had access to the municipal water network that distributes treated and chlorinated surface water. Both companies apply a cross-subsidy regime in a multi-tiered tariff grid to guarantee provision of piped water to the urban poor. The study area of Jatinegara is a district in East-Jakarta with an official population of 262,699 inhabitants living in an area of 10.6 km^2 (March 2002), hence the population density is 24,783/km^2. No sewage system exists in the study area. The municipal water supply in the area originates from a single distribution station. Three rivers cross the area, making the adjacent sub-districts (*kelurahan*) particularly flood-prone.

Three slum-areas have been subject to the KIP which has been implemented in several rounds in Jakarta since 1969 by the City Authorities with support from the World Bank. Its objective was to improve the environmental health and conditions of *kampung* (=slum) dwellers by provision of hand-powered pumps, public toilets, roads, and wastewater drainage.

From March 2002 to February 2003, within a typhoid fever risk factor study (Vollaard *et al*, 2004) we randomly selected 378 households in every third *rukun tetangga* (RT) of a total of 1,140 RTs, an RT being the smallest administrative unit comprising 40-60 households. The primary food handlers in the households, housewives, were approached for a standardized and validated interview. Among other factors, questions included demographic and socio-economic characteristics, drinking water sources, human waste and wastewater disposal of the households and diarrheal episodes of household members in the 3 months preceding the interview. Diarrhea was defined as three or more liquid stools per day. Informed consent was obtained from all respondents. This study was approved by the Indonesian National Institute of Health Research and Development (*Litbangkes*) and provincial authorities.

Water sample collection

During the study period, 341 samples from running drinking water sources were collected from each of the 8 sub-districts in at least 6 distinct months. In 45 households, purchased mineral water was used for consumption; from these 9 mineral water bottles (20%) were examined. A 150 ml sample was collected in sterilized bottles according to WHO-guidelines (WHO, 1997). Faucets of piped water and pumps were sterilized and water kept running for one minute before samples were collected. Piped water samples were collected in bottles containing 0.1 ml of 10% sodium-thiosulphate to neutralize the bactericidal effect of chlorine during transport. Water samples were stored in cool boxes with ice and processed within 6 hours after collection in the central water examination laboratory. Samples were examined for total and fecal coliform counts by the Most Probable Number method: serially diluted water samples were incubated in endolactose broth and brilliant green to detect specific color changes and gas formation. Fecal contamination was defined as the presence of fecal coliforms (≥ 1 MPN Index/100 ml) (WHO, 1997). The upper detection limit was

1,600/100 ml. End-point free chlorine residuals (ppm) had been determined in the study area by Thames PAM Jaya using colorimetry as part of their standard control measurements. Rainfall measurements were obtained from Halim Meteorology Station in East Jakarta.

Statistical analysis

Data from the questionnaires were entered twice using EpiInfo 6.04b software (CDC, Atlanta, USA) and after validation imported into SPSS (SPSS Inc, Chicago, Ill) for statistical analysis. For numerical values the median and interquartile range (IQR) are given. Mann-Whitney *U* tests were used for comparison of not-normally distributed numerical data from two groups and Kruskal Wallis tests for data from more than two groups. For the comparison of proportions between groups, chi-square tests (χ^2) were used. Measures for association were expressed as odds ratios with their confidence limits [OR (95%CI)] for categorical variables. Correlation between variables was tested by a univariate procedure in a regression analysis using a general linear model. To control for confounding factors, multivariate analysis was performed using logistic regression with a variable selection using a forward likelihood ratio test with significantly associated variables from the univariate analysis. Significance levels were set at $p<0.05$.

RESULTS

Demographic data

The characteristics of the 378 households that were visited are given in Table 1. In total, 123 households were included from the KIP-area and 255 from the non-KIP-area, the latter having a significantly lower population density ($p = 0.05$) (Table 2). No significant differences in demographic variables, such as income and median number of household members, were found between the areas.

Water source

Most residents (64%) used groundwater extracted by electrically or hand-powered pumps from boreholes (Table 3). The reported depth ranged from 3 to 35 meters (mean 16 meters). Only 5 households used public pumps (2%), the others had access to privately constructed boreholes in their houses. Twenty percent of the households used the water mains as the source of drinking water and 12% drank bottled mineral water (Table 3). The latter households also had connections to the water mains (30%) or boreholes (70%) from which water was used for personal hygiene and/or food preparation. Only very small proportions used water from unprotected dug wells (2%) or water from vendors (2%) as a source of drinking water.

The high-income group more often had a private connection to the water mains than the low-income group (55% and 44%, respectively), but the difference was not significant ($p = 0.09$). Consumers of bottled water were left out of this comparison. This group had a significantly higher income than the users of other sources (84% *vs* 47%, respectively) ($p < 0.001$).

Fewer pumps were present in households in the KIP-area compared to the non-KIP area

Table 1
Characteristics of 378 households in the study area of Jatinegara, Jakarta.

Variables	Households
Educational level of the head of the family[a]	
Primary school	140 (37%)
Higher education	234 (62%)
Profession of the head of the family	
Self employed / private sector	209 (55%)
Blue collar worker	56 (15%)
Housewife	37 (10%)
Civil service	32 (8%)
Unemployed	24 (6%)
Retired	16 (4%)
Student	4 (1%)
Median number of household members (IQR)	6 (4-7)
Family income[b]	
Median	900,000 Rp
Ownership of the house	
Self-owned	326 (86%)
Rented	52 (14%)

[a]Data missing for 4 respondents, head of the family = breadwinner and/or most senior household member
[b]Exchange rate Indonesian Rupiah: US $1 = Rp 9400 (June 2004)

Table 2
Comparison of districts subject to the Kampung Improvement Project (KIP) and other districts in Jatinegara, Jakarta.

Characteristics	KIP-area	Non-KIP area	OR (95% CI)	p-value
Interviewed households (n)	123	255		
Population density (km^2)	36,670	20,412		0.005
Years of residence (median, IQR)	25 (8-36)	20 (7-31)		0.19
Number of household members (mean, range)	5.7 (2-14)	6.4 (1-50)		0.11
Low income[a]	58 (47%)	124 (49%)	OR 0.94 (0.61-1.45)	0.79
Water source[b]				
Water mains	31 (25%)	46 (18%)	OR 1.53 (0.91-2.57)	0.11
Pumped groundwater	69 (56%)	173 (68%)	OR 0.61 (0.39-0.94) [d]	0.03
Sanitation[b]				
Use of private toilet	91 (74%)	235 (92%)	OR 0.24 (0.13-0.45)	<0.001
Use of public toilet	21 (17%)	16 (6%)	OR 3.08 (1.54-6.13)	0.001
Toilet disposal				
Septic tank	69 (66%)	214 (89%)	OR 0.23 (0.13-0.41) [d]	<0.001
Garbage disposal[b]				
In river/gutter	38 (31%)	21 (8%)	OR 4.98 (2.77-8.97) [d]	<0.001
Drinking water quality[c]				
Presence of fecal coliforms	54 (51%)	137 (60%)	OR 0.70 (0.44-1.11)	0.13
Median fecal coliforms (IQR)	23 (4-300)	23 (6-220)		0.77

[a]Below median income for all households (< Rupiah 900,000)
[b]Respective category was compared to the other categories
[c]Bottled water was excluded from comparison, comparison of numbers: Mann Whitney *U* test
[d]Independently associated in multivariate analysis

(56% *vs* 68%, p = 0.03), but the expansion of the water mains compensates for this deficit, because more residents in the KIP-area had a private connection to the water mains than in the non-KIP areas (25% *vs* 18%, respectively, p = 0.11) (Table 2).

Bacteriologic quality of drinking water

In 33 water samples only total coliforms, but no fecal coliforms, were detected (Table 4). Piped water was less often fecally contaminated than the other sources [OR 0.10 (0.05-0.19)]. In contrast to the 57 (24%) pumped groundwater samples, only 2 (3%) of piped water samples contained more than 100 fecal coliforms/100 ml (p < 0.001), a level of contamination classified as high risk (WHO, 1997). However, the comparison of the median numbers of fecal coliforms in contaminated piped water and those from pumped groundwater [4 (IQR 2-50) versus 23 (IQR 6-280) fecal coliforms/100ml, respectively] showed that the difference with groundwater was non-significant (p = 0.07, Mann-Whitney *U* test).

Three mineral water bottles contained total coliforms, including one bottle with fecal coliforms. These bottles had been refilled in local refill outlets after prior use. Water from dug wells and water vendors had particularly high rates and levels of contamination (Table 4).

Sanitation

Most residents (86%) used private toilets in their houses and smaller proportions used public toilets (10%) or the riverbank (4%) (Table 5). In 86% of the private toilets, excreta were collected in on-site septic tanks. Human excreta and wastewater were directly disposed into rivers or gutters by 98 households (26%), including the 46 households with a private toilet but without an on-site septic tank.

We calculated the hypothetical distance between all septic tanks in the Jatinegara study area using the data from our study group. Assuming a median number of household members of 6, and that 86% of the households had a private toilet, of which 86% had a septic tank, we found a radius of 10.2 m for each septic tank in a total study area of 10.6 km^2 with 263,000 inhabitants.

Besides human excreta, garbage was also disposed into rivers or gutters by 16% of households.

In KIP-area sanitation lagged behind, because significantly fewer households used private toilets (74 *vs* 92% in non-KIP-area) and consequently more often public toilets were used (17 *vs* 6%, respectively) (Table 2). The disposal of the private toilets in KIP-area was less frequently collected into septic tanks than in non-KIP area (66 *vs* 89%, respectively, $p < 0.001$). Garbage was more frequently thrown into gutters or rivers in KIP-area than in the other area (31 *vs* 8%, $p < 0.001$).

Table 3
Water provision.

Variables	Households (%)
Drinking water source	
Boreholes (pumped groundwater)	243 (64)
Connection to water mains	77 (20)
Bottled water	45 (12)
Water from vendors	7 (2)
Dug well	6 (2)
Water used for washing food and dishes[a]	
Groundwater from boreholes	286 (74)
Piped water from water mains	88 (23)
Other sources	13 (3)

[a]Non-boiled water. Answer given by 387 food handlers in the households.

Factors influencing the contamination rate and level

Distance to the river. Fecal contamination was not confined to areas immediately bordering the rivers (Fig 1) nor to one of the 8 sub-districts ($p = 0.38$, χ^2). This lack of association persisted if pumped groundwater samples were analyzed separately ($p = 0.65$). The number of piped water samples in some sub-districts was too small to allow statistical comparison of contamination rates and levels in piped water between the distinct sub-districts. The number of fecal coliforms in all samples was not significantly different for the 8 distinct sub-districts ($p = 0.40$, Kruskal Wallis test), nor when analyzed for pumped groundwater separately ($p = 0.68$).

Seasonality. The fecal contamination rate of all water samples did not vary significantly per month ($p = 0.13$, χ^2) (Fig 2), nor when piped water was analyzed separately ($p = 0.63$) or for the pump water samples only ($p = 0.64$). No significant differences in the numbers of fecal coliforms per month were demonstrated for piped water samples ($p = 0.46$, Kruskal Wallis test) or pumped water ($p = 0.53$).

KIP-area. Contamination rates (51% *vs* 60%, $p = 0.13$) and levels ($p = 0.77$) in the KIP and non-

Table 4
Bacterial contamination of drinking water sources.

Water source (number of samples)	≥1 total coliforms/ 100 ml	≥1 fecal coliforms/ 100 ml	Total coliforms/ 100 ml[a]	Fecal coliforms/ 100 ml[a]
Water pump (243)	195 (80%)	167 (69%)	30 (2-900)	23 (6-280)
Piped water (76)	15 (20%)	13 (17%)	0 (0-0)	4 (2-50)
Bottled water (9)	3 (33%)	1 (11%)	36	-
Water from vendors (7)	6 (86%)	5 (71%)	140 (2-1,600)	170 (12-535)
Dug wells (6)	6 (100%)	6 (100%)	590 (88-1,600)	102 (7-1,600)
Total (341)	225 (66%)	192 (56%)	220 (28-1,600)	23 (6-240)

[a]Median (IQR) MPN Index per 100 ml in contaminated samples only.

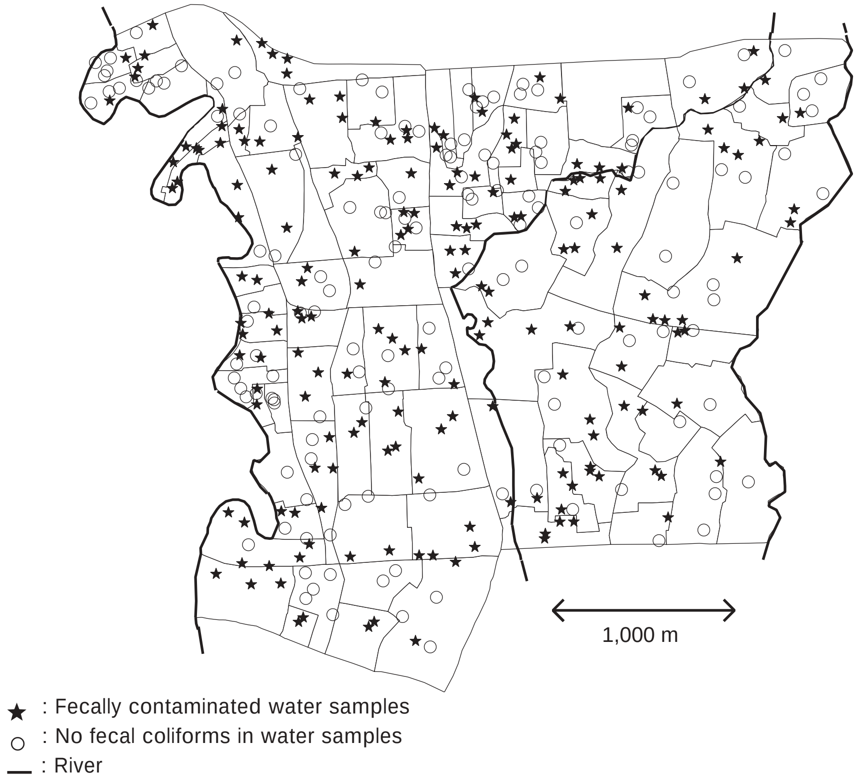

Fig 1–Fecal contamination of drinking water sources of 378 households in Jatinegara, Jakarta.

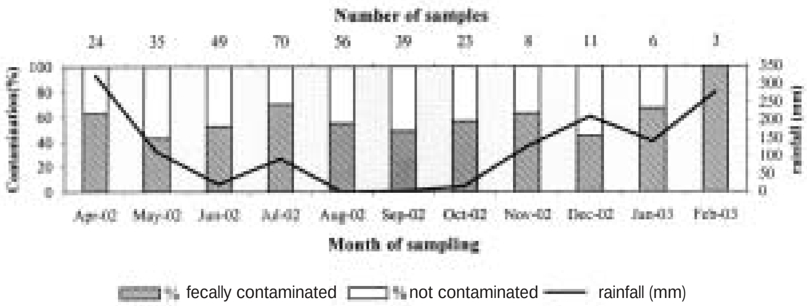

Fig 2–Proportional contamination of samples from groundwater and water mains (n=324) and rainfall per month.

KIP areas were not significantly different (Table 2).

Depth of boreholes. From 168 pumps, both the depth of the borehole and contamination level was known. In a linear regression model for depth of the borehole and numbers of fecal coliforms, the numbers were significantly lower in the deeper boreholes ($p=0.017$, $R = 0.2$), but high bacterial counts were found over the full range of depths. Thirteen outliers (≥1,600 bacteria/100 ml) were not confined to one sub-district in the study area and were mostly sampled in the dry season (11 from 13). The mean depth of boreholes containing less than 100 fecal coliforms/100 ml was 17.0 m compared to 14.2 m in those with >100 bacteria/100 ml ($p = 0.02$).

Chlorination. Thames PAM Jaya monthly measured end-point free chlorine residuals (ppm) at

Table 5
Sanitation and garbage disposal.

Variables	Households (%)
Use of toilet	
Private toilet	326 (86)
Public toilet (with direct disposal onto river)	37 (10)
River banks	15 (4)
Human excreta disposal of private toilets	
Septic tank	280 (86)
River or gutter	46 (14)
Garbage disposal	
Collection by garbage collector	169 (45)
Brought to landfill or container	140 (37)
Thrown in the river or gutter	59 (16)
Burned	10 (3)

17 locations in the study area during the full study period in 2002. An end-point level of 0.3 ppm free chlorine residual is the minimum bactericidal level the water company applies, which was met in 74% of the measurements. In regression analysis, month and location were both independent ($p = 0.03$ and $p < 0.001$, respectively) of influence on the chlorine level, but rainfall was not independently associated ($p = 0.53$).

Diarrheal illness

In 34% of the households diarrheal episodes were reported for at least one of the household members in the 3 months preceding the interview. The occurrence of diarrhea was not associated with the use of other sources than piped water for consumption [OR 1.03 (0.61-1.75)] or for washing food [OR 1.21 (0.74-1.97)]. Also non-associated with diarrhea were flooding [OR 1.40 (0.83-2.33)], the use of private toilets [OR 0.95 (0.52-1.77)], residence in a KIP-area [OR 1.11 (0.70-1.75)] or fecal contamination of the drinking water source [OR 1.09 (0.70-1.72)]. However, in households with water contamination with >100 fecal coliforms /100 ml, diarrhea was reported more frequently (51 *vs* 30%) [OR 2.40 (1.38-4.16)].

All respondents reported boiling their drinking water before consumption, with the exception of the 45 consumers of bottled water and 2 subjects who drank non-boiled water from the water mains. Non-boiled groundwater from boreholes was also used in 74% of food preparation.

Kampung Improvement Program

The significant differences in water supply and sanitation in the areas that had been subject to KIP compared to the non-KIP areas from univariate analysis include: less access to pumped water, less use of private toilets and consequently more use of public toilets, fewer septic tanks and inadequate garbage disposal (Table 2). On multivariate analysis by logistic regression, independent characteristics of the KIP-area were: less access of households to groundwater from pumps as a source of drinking water [OR 0.54 (0.33-0.89)]; more frequent garbage disposal in rivers and gutters [OR 2.89 (1.33-6.27)]; and fewer septic tanks for the collection of human excreta [OR 0.33 (0.17-0.65)].

DISCUSSION

The main finding of the present study in East-Jakarta is that although the supply and quality of drinking water, though frequently fecally contaminated with low bacterial numbers, was largely satisfactory, but human waste disposal and environmental hygiene were poor. Areas subject to the prior Kampung Improvement Program were still lagging behind with respect to sanitation and environmental hygiene. However, the health hazard resulting from the latter situation, as assessed by the frequency of diarrheal illness, was apparently countered by the generally endorsed practice of boiling drinking water before consumption.

With respect to the study design the following should be considered. We examined the drinking water quality at the source and not in containers after storage or boiling. We choose this method to compare the drinking water quality from different water sources, since comparative data are scarce in Jakarta. The only samples that had been stored prior to sampling were those from the water vendors; high numbers of coliforms were demonstrated in these samples. Contamination was most likely caused by unhygienic handling or infrequent cleaning of the water containers. We only examined the microbiological quality of drinking water, therefore nothing can be said about the chemical pollution of groundwater. However, considering the lack of wastewater-treatment in Jakarta and uncontrolled garbage disposal, this problem must be considerable. The occurrence of diarrhea in household members reported by food handlers may be an under-estimation of the true incidence.

Access to water sources in the study area was adequate, because most households had private pumps or connections to the water mains. Freely available groundwater extracted by pumps was the predominant source of drinking water and food preparation. Although a low income can prevent residents from buying bottled water or acquiring a direct connection to the water mains, the projected future scarcity of groundwater in Jakarta may eventually limit its availability. Industrial and domestic over-exploitation of groundwater has caused a drop in the groundwater table with subsequent contamination by seawater (Indonesia Water Resources and Irrigation Reform Implementation Project, Strategic Management Plan Ciliwung-Cisadane, 2003). In the first 4 years of operation (1998-2002) the number of connections to the water system network of Thames PAM Jaya increased 30%. Continuation and further expansion of the existing cross-subsidy system is therefore necessary to compensate for the expected increase in demand for piped water.

Chlorinated piped water was least frequently contaminated. Although no significant differences in the number of fecal coliforms in the contaminated samples from piped water and groundwater were found, groundwater often contained contamination levels of more than 100 fecal coliforms per 100 ml. That contamination level was associated with the occurrence of diarrhea in households, making water treatment at home (boiling or the addition of hypochlorite) crucial for the prevention of diarrheal illness. Below this threshold level, other transmission routes of diarrheal disease (food and personal hygiene) contribute equally or more to the transmission of diarrheal disease, similar to the findings of Moe *et al* (1991). The association may be explained, for instance, by the frequent use of non-boiled groundwater for food preparation, but other factors, such as unhygienic storage of boiled drinking water, might have contributed as well.

We assume that inadequate sanitation and human waste disposal in our study area and the subsequent intrusion of wastewater into water pipes and boreholes was responsible for the contamination of piped water and groundwater, respectively. Four observations have supported this hypothesis.

First, in our study area with a high population density, the septic tanks were located in close proximity to each other. The minimum recommended distance of 10 m between septic tanks and water sources was infrequently met (WHO, 1997; Borchardt *et al*, 2003). The septic tanks require adequate outflow of the liquid effluent and repeated emptying of fecal sludge. Both requirements are hard to enforce, since Jakarta lacks good sewage systems to dispose of liquid effluent and an impaired infrastructure in the overcrowded slum-areas makes emptying difficult or impossible.

Second, the contamination of groundwater samples was evenly spread over the study area. Other factors besides proximity to the river (nearby septic tanks and open gutters) must be associated with fecal contamination as well. The fact that high numbers of fecal coliforms were found in shallow and even in some deep boreholes, demonstrating that groundwater is likely contaminated by the intrusion of wastewater from superficial ground layers into boreholes (and evidently also into dug wells).

Third, uncontrolled garbage disposal in open sewers is complicating the drainage of wastewater. Overflow or leakage from clogged gutters can result in the intrusion of fecal bacteria into adjacent boreholes or water pipes. The *Kampung* Improvement Project, as initiated by the city authorities, did provide for concrete gutters, but participation of the residents in maintenance is essential. Garbage collection in Jakarta is a logistic challenge but necessary to prevent the obstruction of water flowing by direct disposal of garbage into the gutters and rivers.

Fourth, fluctuating levels of chlorination were demonstrated in the samples from the water mains. Intrusion of wastewater into the water mains decreases the chlorination level and consequently bacterial numbers rise. Intrusion is certainly possible, because administrative and technical leakage of the water mains was calculated to cause a loss of 50% of the water supply of Jakarta (Case studies from Dhaka, Jakarta and Manila, Malou Mangahas, Philippine Center for Investigative Journalism, www.adb.org, 2002). As a consequence, water pressure in the water mains is low and the supply is not continuous. Residents store water at home to bridge intervals in supply. This could give rise to contamination of stored water by the immersion of soiled hands or utensils in the water reservoir or by the use of dirty storage vessels (Mintz *et al*, 1995; Jensen *et al*, 2002; Wright *et al*, 2004). Negative pressures during interruptions in the supply and back-siphonage can facilitate intrusion of surrounding wastewater into leaking water pipes resulting in post-treatment contamination of the water mains. This mechanism can cause outbreaks of disease, as was illustrated by a massive typhoid epidemic in Tajikistan in 1997 which was associated with the use of municipal water (Mermin *et al*, 1999). Rehabilitation of the water network, as already initiated by the water company, is consequently a priority in water management, to guarantee the distribution of high quality water and to anticipate the increasing demand for piped water.

In conclusion, the availability of water to most households, the low level of fecal contamination levels in the most commonly used drinking water sources and the entrenched habit of boiling piped and groundwater before consumption, reduce the risk of diarrheal illness in East Jakarta. However, the inadequate disposal of human excreta is a threat to the quality of both piped water and groundwater. With respect to "hardware" interventions in water supply and sanitation, the rehabilitation and expansion of the existing water network combined with a 24-hour water supply (permanent pressure in the water mains) are needed to prevent intrusion of wastewater into pipes and to allow supply of high quality water from the central water network. The separation of human excreta and water provision is essential to prevent this intrusion. Future *Kampung* Improvement Programs should specifically focus on human waste disposal, since water supply in slum-areas is increasingly covered by the expansion of the water network in recent years. Specific "software" interventions by the health sector in Jakarta should address the following issues in public health campaigns: the continuation of boiling groundwater and piped water before consumption; the use of piped water or bottled water for food preparation, warning regarding the high contamination rates and levels in water from dug wells and water vendors, the construction of boreholes of sufficient depth, the monitoring of mineral water refill outlets, the promotion of cheap access to the water mains for the urban poor, adequate garbage disposal, and the construction of septic tanks at a safe distance from water sources with frequent emptying of septic tanks.

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