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Field survey on water supply, sanitation and associated health impacts in urban poor communities – a case from Mumbai City, India

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Abstract A field survey was conducted on four slum, squatter and pavement dweller communities of Mumbai City, India with a total sample size of 1,070 households. Study revealed extremely low water consumption pattern averaging merely 30 l/c.d, no sewerage and safe excreta disposal facilities manifested by high occurrence of water-borne diseases. The annual diarrhoeal, typhoid and malaria cases were estimated to 614, 68 and 126 per thousand populations respectively. At point prevalence scale, at least 30% of all morbidity can be accounted for by water-related infections. In addition to the impacts of neighborhood water pollution and sanitation, such diseases were also found positively correlated with low water consumption and poverty related factors as, poor housing and family income. Analysis of variance also revealed intra-poor gradient both in living standards and health conditions on which the pavement dwellers were observed to be the greatest sufferers of all.

Keywords Field survey; slum and squatters; water-borne diseases; water pollution; water supply and sanitation

Introduction

In the last few decades, cities of the developing world are witnessing the most unprecedented growth rates in their history. Greater Mumbai, the largest city of India, is among such and has grown four-fold in the last four decades and presently stands as the fifth largest urban agglomeration in the world with an estimated population of 15 million in 1995 (UN, 1996). With the rapid urbanization, however, these cities are also inviting many social and environmental problems due to increasing burden of slums and squatters (so-called "urban poor"), deficit and over-straining of existing infrastructure and services, and increasing pollution. In Mumbai, particularly, the ratio and number of urban poor are ever increasing as their share to total city population was merely 12% in 1961 but 51% in 1991 (Sharma and Narender, 1996). The major living sites of urban poor in Mumbai are slums; squatters on pavements, besides railway tracks, water pipelines, under bridges, banks of city drains, marshlands and so on. These urban poor are also understood to be the biggest sufferer group of urban society and major victims of all types of environmental pollution and other epidemics due to their living in pathogen-prone neighborhoods, with cramped conditions in shacks and limited access to basic civic services like safe and adequate water supply, sewerage and drainage, sanitary toilets, solid waste disposal facilities (Hardoy *et al.*, 1997). This paper is aimed at presenting the linkage between living environmental conditions (in the context of urban water pollution and sanitation) and consequent public health implications as revealed after a comprehensive survey conducted during May, 2000 on selected communities of slums, squatters and pavement dwellers of Mumbai City, India.

Overview on Mumbai's water supply and sanitation. Mumbai (Bombay) Municipal Corporation (BMC) presently produces and supply some 3,000 million litres of water per

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day (MLD), however, it has met only about 65% of the total demand (BMC, 2000). This deficit has led to imposing interruption in water supply and also unequal distribution norms among consumers. As per a criterion of BMC, the urban poor living in slum and squatters are apportioned the least, only about 45 l/c.d against 135 l/c.d for those living in condominiums or privately owned houses (YUBA, 1999). Regarding sewerage network, spatially it is said that over 90% of island city and 40–50% of suburbs are covered (Gandhi, 1996), but the real beneficiary population could be much less as more than half of the population are living in slums and squatters and most of them are devoid of this service. In terms of wastewater collection and treatment, however, about 90% wastewater (2,210 out of 2,456 MLD) is being collected of which 109 MLD goes up to secondary treatment, nearly 1,200 MLD through ocean outfalls and rest is simply discharged to local waterways and creeks (CPCB, 1997; Gandhi, 1996). Regarding means of human waste disposal, almost all the urban poor communities rely on either municipal toilets or practicing open defecation. Out of total estimated demand of 36,704 public toilet seats over BMC's land in 1995, it was provided with merely 12,612 and still nearly one-third of them were non-functional due to bad condition (Dsouza, 1999).

Methodology

Site selection and characteristics. Four settlements of urban poor representing slums, squatters and pavement dwellers of Mumbai City, as mentioned in Table 1, were chosen under this study. Muttamariamma Nagar slum is located at Malad, a rapidly developing northern fringe of Mumbai especially in real estates. Dharavi, formerly known as fishermen's village a century ago, is located almost in the centre of Mumbai partitioning the Island City from its suburbs. Presently it is also regarded as the largest slum in Asia inhabited by more than 500,000 people in various clusters. We selected two communities from Dharavi, namely Mukund Nagar (MN), which is relatively older but very crowded and Rajiv Gandhi Nagar (RGN) that is settled on swampy land of Mahim creek, a relatively newer squat. Regarding pavement dwellers (PD), we picked up from more than 15 clusters in various parts of Island City namely, Mahim, Bandra reclamation, Wadala, Matunga, Parel, Worli, Byculla and Sewri.

Data collection and indicators used: The "questionnaire survey" by house interview was employed as method of data collection. The entire slum or pavement community under study was divided into the zones as per the number of interviewers and then random selection of houses were performed in the ratio of nearly 1 in 5. The questionnaire was organized so as to get information on four broad perspectives; socio-economic, infrastructure, environmental health, and behavior and environmental awareness. However, this paper will be mainly focussed on linking the living environment (in light of water pollution) to the health implications. Besides questionnaires, we also performed some water quality analysis of the water samples taken from the tap and drainage channels flowing besides the slums on few

Table 1 Details on study area and sample size

Settlements	Settlement (estimated)		Sample size	
	Household	Population	Household	Population
Muttumariamma Nagar, Malad	1,200	5,700	312	1,486
Rajiv Gandhi Nagar, Dharavi (RGN)	1,500	7,600	358	1,822
Mukund Nagar, Dharavi (MN)	800	4,300	114	611
Pavement dwellers (PD)	unknown	unknown	286	1,316
Total			1,070	5,235

parameters like COD, *E.coli* and pH. Data as obtained after interview were analyzed in Systat 9.0 statistical package for descriptive statistical analysis, ANOVA and correlation matrix of various parameters as presented in this paper.

Results and discussions

Status of living environment with respect to water supply and sanitation

Neighborhood water pollution. Whereas the Muttumariamma Nagar slum is settled along the banks of a sewage-laden highly polluted storm water drain in Malad (see Figure 1), Rajiv Gandhi Nagar Slum is over marshland of Mahim creek, a site where an open city sewer also outfalls into the Creek. Terrain at both places is low-lying and prone to frequent flooding and submergence during rainfall. Water in the drain and creek appeared blackish in color, septic and emitting foul smells, yet children were having frequent contact with such water. Water quality analysis at two locations showed $COD_{(Mn)}$ 350 to 550 mg/l, pH 6.5 and *E. coli* 10^6 to 10^7 MPN/100ml as presented in Table 2.

Water supply. Almost all the people in slum or pavements are relying on the municipal water supply system, however, the ratio of private tap connection at house is much less. Households with own water tap connection is 41% in Mukund Nagar, but only about 2% among pavement dwellers and 9–14% in Malad and Rajiv Gandhi Nagar. Other slum families acquire water from common taps and pavement dwellers from various sources viz. public taps (stand posts), 74%; buying from vendors, 10%; buying from neighbors, 7% and by stealing, 7%. Among slum families sharing a common tap, number of houses per tap was found, in average, 11, 20 and 28 in Mukund Nagar, Rajiv Nagar and Malad respectively. Moreover, the water supply hour in taps is also limited to only 4 hours a day in all the slums studied. In terms of per capita water consumption, it is barely more than 40 l/c.d in any settlements (Figure 2) against the average of Mumbai being 127 l/c.d.

Regarding quality of water supplied in taps, although most of the slum dwellers were assertive on receiving dirty water frequently, none of them are using any scientific devices for bacteria filtration or disinfection except 5–15% of them reported that they boil water. In this regard, BMC itself reports some 10–13% of their samples being contaminated with

Table 2 Water quality of a drain and a creek of Mumbai City (as of May 2000)

Parameters	Drain at Muttum. slum (Figure 1)	Mahim creek at Rajiv Gandhi Nagar slum
$COD_{(Mn)}$, mg/l	450–550	350
pH	6.5	6.7
E-coli (CFU/100 ml)	1.2×10^7	5×10^6

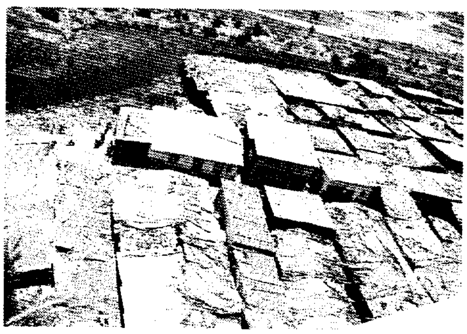

Figure 1 A view of Muttumariamma Nagar Slum and adjacent drain (Photo taken by authors)

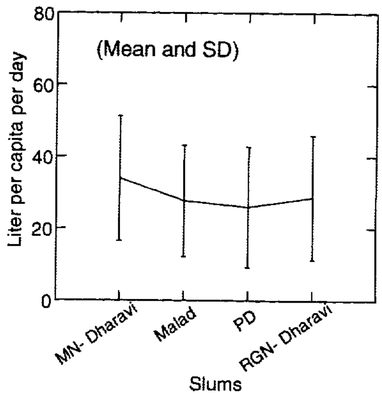

Figure 2 Per capita water consumption in slums

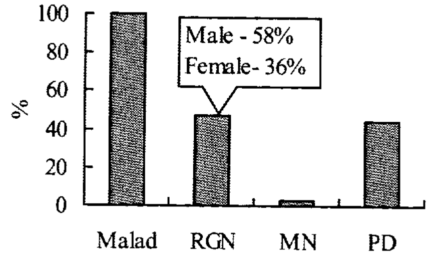

Figure 3 Percent of households practicing open defecation

coliform bacteria (Karande, 2000). However, our *E.coli* examination of few grab samples from taps in the slums, didn't show contamination during the time of survey.

Sewer and sanitation facilities. Except 6% residents of Mukund Nagar, none of the households in Mukund Nagar or at any other slums have sewerage facilities. As a result, all types of domestic wastewater from such houses run past in the open gutter in the alley between the houses and finally discharge either into surface roadside drains or at nearby land or water courses. Access to toilets is another serious problem among all settlements. Private toilet attached to dwelling is virtually non-existent and therefore choice is either to use community or public toilets, wherever provided, or go for open defecation. The entire Muttumariamma Nagar slum doesn't possess any single toilet seat and so everyone is going for open defecation. In RGN-Dharavi too, there is no such community or public toilet within the settlement itself, however, some 42% male and 64% female were found going to far-off community toilets in other parts of Dharavi and rest are practicing open defecation (refer Figure 3). Where there are community toilets, other problems are lack of cleanliness and too many users. We attempted in estimating the number of users per toilet seat by interviewing with some of the regular users that revealed, in average, 129, 93 and 101 persons per toilet seat in Rajiv Gandhi Nagar, Mukund Nagar and pavement dwellers respectively.

Environmental health indicators

As the health status of the people portrays the overall impact due to any of social (poverty etc.) and environmental impairments pertaining to the society, we collected information on the prevalence and intensity of water related morbidity to correlate with the environmental factors. The illness reported in this paper, however, does not necessarily constitute clinically confirmed cases as merely reported by respondents. Due to various social and public awareness reasons, few respondents were also shown reluctant, giving vague or even exaggerated figures while reporting on morbidity that may have caused any deviations from the real situation. Nevertheless, result obtained, in gross, seems adequate enough to reveal the impacts of living environmental factors over the health conditions and intra-urban differences.

Morbidity prevalence rate (MPR). Information on morbidity was collected in two parts: short duration morbidity (SDM) and major or chronic morbidity (MM). Incidence of colds and coughs, unidentified fevers, water-borne diseases etc. that are temporary and acute in nature, were classified as the short duration diseases and enumerated as prevailing during the time of survey. On the other hand, chronic diseases like tuberculosis (TB), asthma, heart diseases, cancer, leprosy etc. were categorized as major diseases. Table 3 presents the details on the ratio of short and acute diseases in various communities. It is found that nearly 35–45% families in slums and over half of pavement dwellers have at least one member always suffering from some kind of illness.

Among short duration diseases, water and sanitation related diseases mainly, diarrhoeal, malaria, typhoid, intestinal worms etc. shared 26–32 percent of all cases.

Prevalence of water-related diseases. In order to take account of seasonal impact on the occurrence of water-borne diseases, we considered last one-year's total morbidity cases on water-related diseases. The details on incidence and prevalence of some selected diseases are presented in Table 4. Annual diarrhoeal cases in pavement dwellers are observed as much as 614 and around 300 cases in slums per thousand population. The lower value as obtained for Malad is unlikely viewing the existing situation but the reason of such biases might be one or more as explained earlier. Although all types of water-borne disease are occurring with great severity in all the poor communities, pavement dwellers seems most affected. Though detailed data are not presented here, children were found sharing almost 2/3rd of all morbidity cases.

Factors affecting water consumption and water-related diseases

A matrix of Pearson correlation coefficients was set up in order to examine the inter-relationships of various parameters and their association within each slum and pavement community. Correlation coefficients reveal that it is not only one but many factors that together are causing the lower water consumption pattern and high morbidity rates in slums besides other external factors like neighborhood pollution and environmental awareness etc. In particular, high family income, more housing space and better housing condition are positively correlated with higher water consumption and vice versa as shown in Table 5. However, surprisingly, higher numbers of families sharing one tap seems having no significant impact (rather slightly reverse relationship) over water consumption pattern.

Table 3 Point prevalence rate (PPR) of short duration and chronic diseases in urban poor

	Malad	RGN	MN	PD
Families with at least one member sick at the time of survey, %				
SDM	29	26	15	32
MM	15	16	19	25
Total	44	42	34	57
Share among SDM, %				
Water related	27	32	26	28
Fever (unknown)	20	11	39	29
Cold and others	53	57	35	43

Table 4 Prevalence rate of some selected water-borne diseases

	Annual cases/000 population			
	Malad	RGN	MN	PD
Diarrhoea	94	287	334	614
Typhoid	36	38	46	68
Cholera	3	26	7	<1
Jaundice	0	30	13	68
Malaria	59	26	44	126
Intestinal worms	98	1	133	353

Table 5 Pearson's correlation coeff. matrix (partial) of some selected parameters

Parameters	Place	Family income per capita	Living space (housing) per capita	House condition (structure)	No. of households sharing one tap	Per capita water consumption
Per capita water consumption						
	Malad	0.28	0.22	0.13	0.12 (–)	
	RGN	0.12	0.28	0.06	0.15 (–)	
	MN	0.38	0.04	0.04	0.07 (–)	
	PD	0.2	0.26	0.30	–0.28*	
Total annual cases of water-related diseases						
	Malad	–0.08	0.02 (–)	–0.1		–0.18
	RGN	–0.08	0.04 (–)	–0.03		–0.23
	MN	–0.17	0.01 (–)	–0.02		–0.04
	PD	–0.15	–0.15	–0.27		–0.25

(–) Reverse relationship to that expected; * "Distance of water source" versus "per capita water consumption"

Similarly, incidence of water-related diseases is observed to reduce with high water consumption and to some extent by housing condition and income but unaffected by housing space.

Analysis of variance (ANOVA)

One-way analysis of variance (ANOVA) investigation was carried out in Systat's ANOVA model in order to test the inter-slum variations on the status of some selected parameters. The null hypothesis assumed was no differences in the means of samples (of individual slums) and the entire populations from which it was drawn (i.e. H_0: $\mu_{Malad} = \mu_{RGN} = \mu_{MN} = \mu_{PD}$). The summary results of various ANOVA investigations are presented in Table 6. As revealed from ANOVA results, it can be said that inter-slum variations in terms of water consumption, housing spaces and population load in community toilets are minimal i.e. they bear almost same type and severity of problems. Rejections of null hypotheses are led, mainly, by marginal values of pavement dwellers, which, in many cases as depicted in earlier sections, is the worst of all.

Conclusions

Study conducted on the urban poors of Mumbai City showed significantly high incidence of water and sanitation related diseases in slum and squatter communities than elsewhere. The environmental problems in slums are aggravated due to a number of factors like: their location at environmentally unsafe sites (near polluted waterways), no sewerage and sanitation in the communities, poor personal hygiene due to less availability of water, poverty and lack of environmental education. While the environmental conditions and consequent human sufferings are almost comparable among various slum communities, they appear much harsher for pavement dwellers as resulted from ANOVA analysis. The girth of the

Table 6 Summary of analysis of variance (ANOVA) results

Parameters under test	Degree of freedom (df)	F-ratio	Probability, p	Null hypothesis at 1% significant level
Per capita water use (all, including PD)	3, 1030	4.004	0.008	Rejected
Per capita water use (slums only)	2, 749	2.440	0.088	Valid
Families sharing one tap (slums only)	2, 746	38.975	<0.005	Rejected
Population per toilet seat (slums only)	2, 225	2.575	0.078	Valid
Housing space, per capita (all)	3, 938	9.131	<0.0005	Rejected
Housing space, per capita (slums only)	2, 690	3.344	0.036	Valid

problem lies on the fact that Mumbai is now almost overwhelmed by more than 7 millions slum and squatter settlers and their ratio is expected to increase in future. Although the entire solution may lie in a multi-sectoral approach and achievements including overall socio-economic development of the nation, provision of safe and adequate water and sanitary facilities in the slums and effective wastewater management seems among major issues of immediate concern for reducing the burden of such diseases and consequent impairments.

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