EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 7
Issue: 3
360-367
Year: 2020

ASSOCIATION OF STORAGE AND SANITARY PRACTICES WITH BIOLOGICAL QUALITY OF DRINKING WATER AT HOUSEHOLD LEVEL IN NORTHERN INDIA: A CROSS-SECTIONAL STUDY

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Article Received on 14/01/2020 **Article Revised on 04/02/2020** **Article Accepted on 24/02/2020**

ABSTRACT

Background: About two third of India's surface water is contaminated which has led to crisis of ground water over use. The data available on quality of water supply at household level is limited. So, this study was conducted to assess the association of storage, sanitary practices with biological quality of drinking water. **Materials and Methods:** Required sample size was calculated using formula $4pq/E^2$ and equal number of households (170 each) were selected from urban, rural and urban slums of study area using Systematic Random Sampling (SRS). Prior to this, Probability proportionate to size (PPS) was used to select eight urban wards, ten villages and four urban slums from which a total sample size of 510 was drawn. After interviewing the eldest member of the household, information on socio-demographic profile, drinking water storage and sanitation practices followed at household level were recorded in a semi-structured questionnaire. **Results:** Water storage practices at household level observed, majority 282 (55%) stored drinking water in camphor, 474 (93%) of containers had wide mouth (> 5cm) and 464 (91%) containers were covered. Out of 102 drinking water samples 73 (72%) were found to be bacteriologically contaminated and contamination was found to be associated with place of residence (aOR =1.7; 95% CI= 0.964-3.03), container without tap (aOR =3.6; 95% CI= 1.3-10.2) and drinking water treatment (aOR =1.9; 95% CI= 0.6-5.1). **Conclusions:** Overall water storage practices were satisfactory in the households of urban areas but bacteriological quality of drinking water was poor for all three areas under study.

KEYWORDS: Drinking water, Biological quality, Sanitary facility, Storage.

INTRODUCTION

Water is essential for survival of all living organisms on earth and we humans cannot survive for more than a few days without water. Though there are three main sources of drinking water: Rain water, surface water and ground water but ground water is the most exploited. India is the largest user of groundwater in the world, as 85% of drinking water supplies are dependent on groundwater.[1] About two third of India's surface water is contaminated.[2] Availability of safe water at household level seems to be an increasing concern and moreover national drinking water assessments do not reflect local variability. So we planned to conduct this study in urban, rural and urban slum areas in one of the district of northern region of India to assess the drinking water storage practices along with biological quality of water as well as water purification and sanitary practices adopted at household level.

MATERIALS AND METHODS

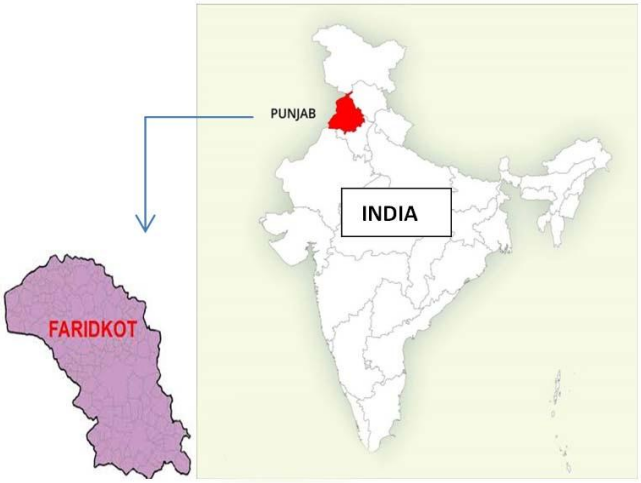

Figure 1

A cross sectional study was conducted over one year (2018-2019) in one of the 22 districts of state of Northern India (Punjab) situated between 29° 33' N to 32° 32' N latitude and 73° 53' E to 76° 56' E longitude with population of 617,508. Out of the three blocks in the district, one was randomly selected which consisted of 22 urban wards, 9 urban slums and 102 villages of rural area. Sample size was calculated by the formula n >4pq/E^2× deff, where n is minimum sample size required, p was taken to be 85.5%[3], E the desired relative error was assumed to be 7% and deff (design effect) of 1.2. Therefore, a total of 510 households (170 each from urban slums, urban wards and villages) formulated the sample size. Sampling technique used is shown in the figure 2. House to house survey was conducted during which eldest member present at the time of visit was interviewed (preferably female). Relevant information was recorded on a semi-structured questionnaire developed. Sanitation facilities, drinking water storage and treatment practices at household level were directly observed during the survey. Drinking water samples of 20% of household included in the study were selected by quota sampling and were subjected to bacteriological quality analysis which was done by Bacteriological Water Testing Kit (BWTK) developed by Punjab Agriculture University (PAU). When there is no change in color of the kit it is Biologically potable (Negative as per BWTK) and when color of the kit changes to yellow it is biologically non-potable (Positive as per BWTK). Ethical approval was obtained from ethical committee of the institution. A written informed consent from respondent was obtained for participation in the study. Confidentiality was maintained at all levels. If selected household was found to be locked or failed to give written informed consent, immediate next household was included to complete the sample size. Households with respondent < 18 years of age were also excluded. The completed data collection tool was coded using pre-arranged coding sheet to minimize errors and questionnaire was developed in Epi Info 07 (CDC, USA). Data was compiled and analyzed using the same. Descriptive statistics in form of frequencies/proportions were calculated for categorical variables. Data was represented in form of tables and graphs (whichever was appropriate) for easy interpretation. To assess the variation of variables across different areas (urban slums, urban and rural areas) chi square analysis was used. To find the determinants/association of bacteriological drinking water quality, bivariate logistic regression analysis was done after exporting the data set from Epi Info to SPSS 20.0.(IBM). Dependent variables were measured as a binary outcome in form of: Bacteriological test – positive = '0', negative = '1'. Socio-demographic profile, sanitary facility, storage practices, water treatment practices, etc. were independent variables. Strength of association were expresses as OR (95% CI). Following multinominal logistic regression analysis was done where p value ≤0.20 was taken as a elimination criteria. The results were expressed as aOR (95% CI). At any point p value of <0.05 was considered significant.

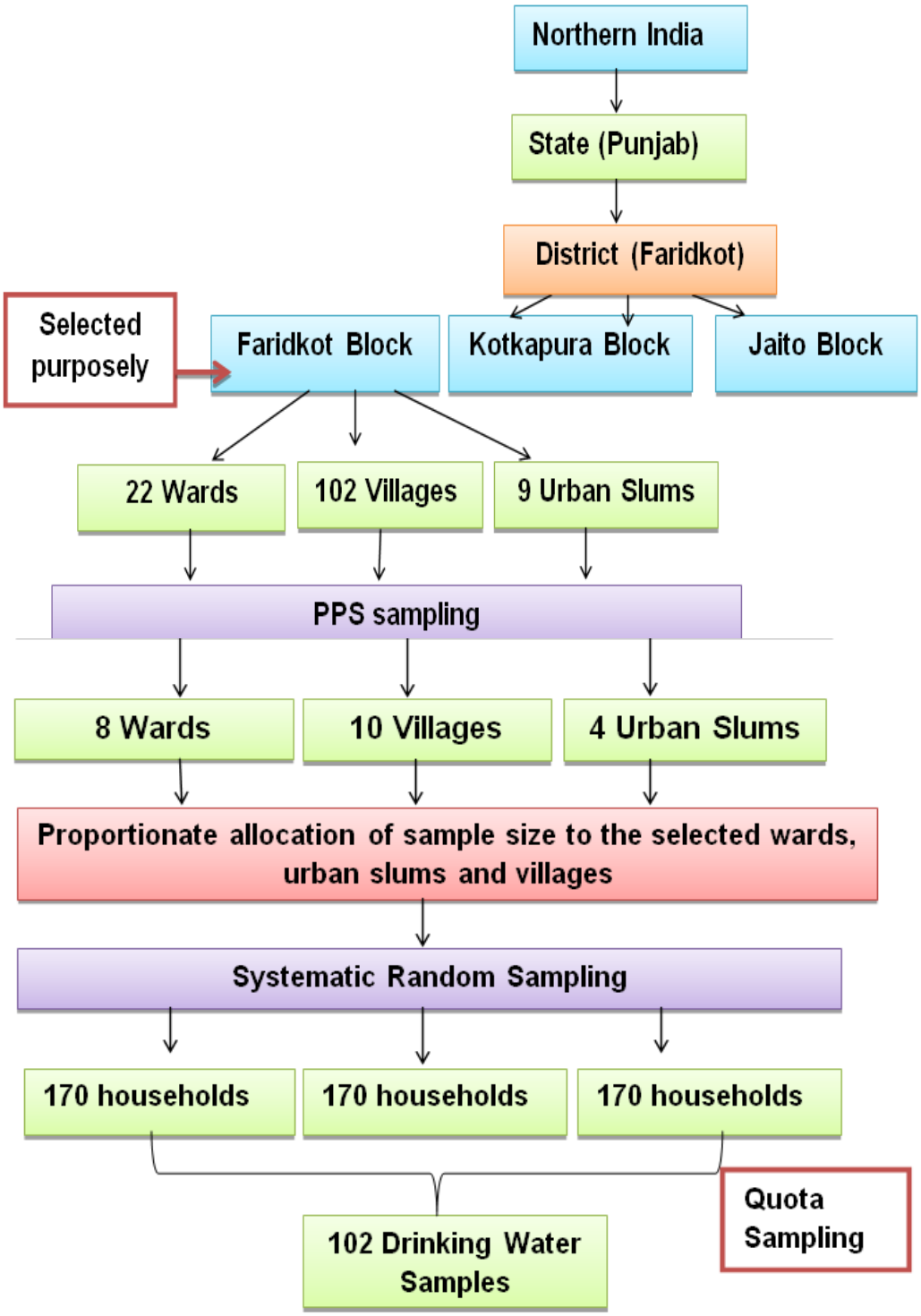

Figure 2: Sampling technique used in the study.

Procedure of collection of drinking water samples

Drinking water samples for the same were collected as per the quality control procedures from Punjab Agriculture University (PAU) using sterile technique. After collection of samples, they were transported in cold box and analyzed within 2-4 hours. For testing, 15 ml of water samples was added to BWTK which is violet in colour (figure 3). Timing of addition of water to the kit was noted and kept at room temperature for 12 hours with cap on, after which any colour change was noted. (Yellow colour showed bacterial contamination (figure 5).

Figure 3: Bacteriological Water Testing Kit.

Figure 4: Bacteriologically negative.

Figure 5: Bacteriologically positive.

RESULTS

Out of 510 households surveyed, it was found that 8 households in urban slums, 10 households in urban and 7 households in rural area were found to be locked, so immediate next household was taken into consideration and thus a total of 170 household each from urban slums, urban and rural area were surveyed and drinking water storage practices along with bacteriological quality as well as water purification practices adopted were studied. 430 households under the study had a per capita income of INR 7053 (84%) therefore belonged to upper class (according to BG Prasad's classification) (table 1).

Area-wise distribution of households according to drinking water storage practices is shown in the table 2. As far as water handling practices were concerned, it was found that only 6 (1%) households practiced hand washing before taking out drinking water. Among those not using containers with tap and bottles, only 9 households (5%) used cup with handle to take out drinking water from the container. The present study shows that overall 376 (74%) households did not treat drinking water before consumption. Water treatment practices varied over the areas, as 155 (91%), 145 (85%) and 76 (45%) of the household situated in urban slums, rural areas and urban areas did not treat drinking water before consumption. This difference was found to be statistically significant. Out of total 134 households who treat drinking water before consumption, 130 (97%) households used water filter and not much difference was observed in different setting. The reasons for non-treatment of drinking water were also found which are shown in table 3. As far as episodes of diarrhea/dysentery was concerned, 61 (36%), 47 (28%) and 18(11%) households of urban slums, rural area and urban area experienced one or more episodes in last three months. The overall difference was found to be statistically significant. The bacteriological quality of drinking water was assessed in 102 households. It was found that overall 73 (72%) samples were bacteriologically contaminated and overall area-wise distribution of bacteriological quality of water is shown in the figure 1. The bacteriological quality of drinking water was found to be associated with availability of tap on containers (table 4). The odds of having poor bacteriological quality of drinking water was 3.9 (95% C.I.= 1.4-10.8) times higher among those who stored drinking water in containers without tap in comparison to those storing drinking water in containers with tap. Mouth of container (cOR = 2.0; 95% C.I.= 0.2-18.4) and practice of treating drinking water (cOR = 2.2; 95% C.I.= 0.8-5.8) were not found to be associated with bacteriological quality of drinking water. On Multinomial logistic regression analysis, storage containers without tap was found to be associated with bacteriological quality of drinking water (aOR = 3.6; 95% C.I.= 1.3-10.2) (table 5).

Table 1: Area-wise distribution of households according to socio-demographic profile (N=510).

Variables	Urban slums (n_1=170)	Urban (n_2=170)	Rural (n_3=170)	Total ($n_1+n_2+n_3$)
Religion				
Sikh	54(32)	105(62)	153(90)	312(61)
Hindu	110(65)	64(37)	16(9)	190(37)
Others	6(3)	1(1)	1(1)	8(2)
χ^2 = 123.2, p = 0.000, df = 4				
Caste				
SC	105(62)	45(26)	96(56)	246(48)
OBC	18(11)	11(6)	6(4)	35(7)
General	33(19)	108(64)	67(39)	208(41)
Others	14(8)	6(4)	1(1)	21(4)
χ^2 = 84.7, p = 0.000, df = 6				
Type of family				
Nuclear	102(60)	117(69)	107(63)	326(64)
Joint	68(40)	53(31)	63(37)	184(36)
χ^2 = 2.98, p = 0.225, df = 2				
BPL card				
Yes	29(17)	43(25)	102(60)	174(34)
No	141(83)	127(75)	68(40)	336(66)
χ^2 = 78.56, p = 0.000, df = 2				
Socio Economic Status				
I(7053 & above)	118(69)	170(100)	142(83)	430(84)
II(3527- 7052)	37(22)	0	23(13)	60(12)
III(2116-3526)	10(6)	0	3(2)	13(2)
IV(1058- 2115)	2(1)	0	1(1)	3(1)
V(1057 below)	3(2)	0	1(1)	4(1)

Table 2: Area-wise distribution of households according to drinking water storage practices (N=510).

Variables	Urban slums (n_1=170)	Urban (n_2=170)	Rural (n_3=170)	Total ($n_1+n_2+n_3$)
Type of container				
Bucket	54(32)	1(1)	32(19)	86(18)
Drum	51(30)	6(3)	55(32)	112(22)
Camphor	65(37)	142(84)	75(44)	282(55)
Bottles	1(1)	21(12)	8(5)	30(5)
χ^2 = 145.3, p = 0.000, df = 6				
Width of mouth of container				
Wide mouth> 5 cm	163(96)	153(90)	158(93)	474(93)
Narrow mouth< 5cm	7(4)	17(10)	12(7)	36(7)
χ^2 = 4.48, p = 0.106, df = 2				
Container has tap				
Yes	70(41)	143(84)	77(45)	299(59)
No	100(59)	27(16)	93(55)	211(41)
χ^2 = 77.81, p = 0.000, df = 2				
Container is covered				
Yes	137(81)	168(99)	159(94)	464(91)
No	33(19)	2(1)	11(6)	46(9)
χ^2 = 34.5, p = 0.08, df = 2				

*Figures in parenthesis are percentages; p value <0.05 is significant.

Table 3: Area-wise distribution of households according to reasons for non-treatment of drinking water (N=376).

Variables	Urban slums (n_1=155)	Urban (n_2=76)	Rural (n_3=145)	Total ($n_1+n_2+n_3$)
Treatment systems not available	67(43)	0	0	67(18)
Water from source is clean	38(25)	73(96)	96(66)	207(55)
Treatment technology is expensive	50(32)	3(4)	49(34)	102(27)

*Figures in parenthesis are percentages.

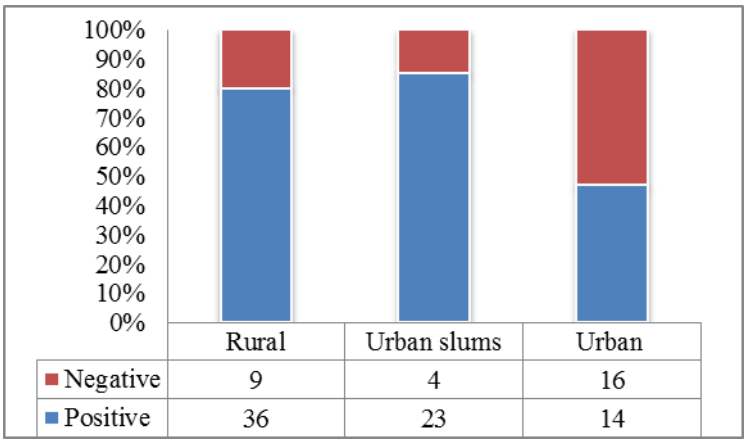

Figure 1: Area-wise distribution of households according to bacteriological drinking water quality (N=102)
χ^2 = 13.17, p = 0.001, df = 2

Table 4: Binary logistic regression analysis showing association of drinking water storage and treatment practices with bacteriological quality (N=102).

Variables	BWTK		cOR (95%C.I.)	P value
	Positive (n=73)	Negative (n=29)		
Area				
Urban	14(47)	6(53)	1	0.004
Urban Slums	23(85)	4(15)	4.5(1.6-12.7)	
Rural	36(80)	9(20)	0.6(0.1-2.5)	0.581
Width of mouth of container				
Wide mouth (>5cm)	68(71)	28(29)	1	0.518
Narrow mouth (<5cm)	5(83)	1(17)	2.0(0.2-18.4)	
Container has tap				
Yes	36(61)	23(39)	1	0.008
No	37(86)	6(14)	3.9(1.4-10.8)	
Do you currently treat your drinking water				
Yes	14(58)	10(42)	1	0.105
No	59(76)	19(24)	2.2(0.8-5.8)	

*Figures in parenthesis are percentages; p value <0.05 is significant.

Table 5: Multinomial logistic regression analysis for factors associated with bacteriological quality of drinking water (N=102).

Variables	aOR (95%C.I.)	P value
Area	1.7 (0.964-3.03)	0.067
Container without tap	3.6 (1.3 -10.2)	0.012
Currently treating drinking water	1.9 (0.6 -5.1)	0.209

* p value <0.05 is significant.

DISCUSSION

A total of 510 households in the study setting were visited. From urban slums, urban area and rural area, 170 households each were selected using systematic random sampling.

According to socio-economic grading of households in the study 84% belonged to upper class according to modified BG Prasad scale. The literacy rate was 60% in our study which is slightly lower than that reported by census 2011 for Faridkot district (69.6%).[4] This could

have been skewed due to inclusion of urban slums where 64% of head of family were illiterate.

In the current study, 55% of household used camphor for storing drinking water whereas 40% stored it in plastic drums and buckets. In contrast a study done by Kanianmbady S et al in Karnataka reported that 62.3% of the households used buckets/drums to store water.[5] This difference could be because of the socio-economic difference in both the study population as 84% belonged to upper class in our study.

Only 1% of the households in our study reported to practice hand washing before taking out water. But a relatively higher proportion of households (31.7%) reported to wash hands before taking out water according to a study conducted by Mishra et al.[6] this could be attributed to low literacy level and lack of awareness of the study population.

In a study done in Uganda, over 90% of the participants treated their drinking water, and the most popular method for treating water was boiling[7] whereas 26% treated drinking water before consumption in the present study. Only 55%, 15%, 9% households of urban, rural and urban slum areas treated drinking water. Among those who treated drinking water, water filter was the commonest practice. Another study in done by Kaniambady S in Karnataka showed 76.92% of the households boiled water prior to consumption, 5.76% of the households boil the water first followed by filtering the water by candle filters, 2.69% of the households used either water filter/ water purifier, 14.23% of the households did not use any water treatment methods before consumption, of which majority (51.35%) belonged to lower socio economic class.[5]

A total of 102 drinking water samples, were collected from the study area. Of the total samples, 73(72%) samples were found to be bacteriologically contaminated. Maximum contamination was present in samples from urban slums (85%) and lowest in urban area (47%) which is in consistent with other studies conducted in other Indian cities such as Madurai (47%), Delhi (43%), Vellore (93%), Hyderabad (4%) and Chandigarh (30%).[8]

On binary logistic regression the biological quality of drinking water was found to be associated with area, and availability of tap on containers. On multinomial logistic regression analysis, various factors found to be associated with poor bacteriological quality of drinking water storage containers without tap (aOR = 3.6; 95% C.I.= 1.3-10.2). In a study done in Uganda, Multivariate Robust Poisson Regression Analysis of total coliform in household drinking water showed that the practices associated with total coliform contamination in household drinking water were age, education, occupation, water storage container and method of water treatment. Safe drinking water supply to the developing communities is difficult to achieve beyond the water source because it becomes contaminated during the processes of fetching water in containers over the distance between home and supply source, as well as storing and using it at home due to poor hygienic practices.[7]

Some limitations of the study are: Results were based on cross-sectional study due to resource constraint but a longitudinal assessment measuring seasonal variations in quantity and quality would have been better. BWTK was used to test bacteriological water quality. Only positive and negative could be classified but the organisms contaminating the water were not tested as PCR needs to be done and it was not available.

CONCLUSION

Overall water storage practices were satisfactory in the households of urban areas but bacteriological quality of drinking water was poor for all three areas under study. Safe drinking water supply to the developing communities is difficult to achieve beyond the water source because it becomes contaminated during the processes of fetching water in containers over the distance between home and supply source, as well as storing and using it at home due to poor hygienic practices.

FINANCIAL SUPPORT AND SPONSORSHIP: Nil.

CONFLICTS OF INTEREST: There are no conflicts of interest.

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