Assessment of drinking water quality, related health impacts and accessibility to public health curative services among slum dwellers in Dehradun city of Uttarakhand, India.

Evaluación de la calidad del agua potable, los impactos en la salud relacionados y la accesibilidad a los servicios curativos de salud pública entre los habitantes de los barrios marginales de la ciudad de Uttarakhand, India, en Dehradun.

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ABSTRACT

The child population in slums of Dehradun city is at significant risk of water borne diseases. Thus study aimed to assess the bacteriological quality of drinking water during pre and post monsoon months for five different slum locations of Dehradun city and water related diseases affecting the child population of 0-5 years of age during the post monsoon month. Also perception study of slum dwellers has been carried out regarding accessibility to public health care services and various barriers to it. In total 30 drinking water samples from point of use were collected from five slums during the months of May and August and bacteriological analysis was done using standard methods. Health related information based on prevalence rate of water borne diseases was gathered through pre-designed survey questionnaires. Results showed that all water samples were found highly contaminated during post monsoon month with mean values of Total Coliform at 1129.52±970.28 count/100 mL and $E.coli$ at 22.37±11.74 count/100 mL respectively. The point prevalence rate of Diarrhea among all

children was found to be highest i.e. 45 percent out of five diseases. In addition, total cases of child population affected by water related diseases was found negatively correlated with various social and environmental factors. Public health care services for the medical treatment was only preferred by 26 percent of slum dwellers due to existence of various barriers.

Keywords: Child Health; Bacteriological Analysis; Public Health Service; Water borne Diseases; Socio- Economic Factors.

RESUMEN

La población infantil de los barrios marginales de la ciudad de Dehradun corre un riesgo significativo de contraer enfermedades transmitidas por el agua. Por lo tanto, el estudio tuvo como objetivo evaluar la calidad bacteriológica del agua potable durante los meses anteriores y posteriores al monzón en cinco lugares diferentes de tugurios de la ciudad de Dehradun y las enfermedades relacionadas con el agua que afectan a la población infantil de 0 a 5 años durante el mes posterior al monzón. También se ha realizado un estudio de percepción de los habitantes de los barrios marginales con respecto a la accesibilidad a los servicios de salud pública y las diversas barreras a la misma. En total, se recolectaron 30 muestras de agua potable del punto de uso de cinco barrios marginales durante los meses de mayo y agosto y se realizaron análisis bacteriológicos utilizando métodos estándar. La información relacionada con la salud basada en la tasa de prevalencia de enfermedades transmitidas por el agua se recopiló mediante cuestionarios de encuestas prediseñados. Los resultados mostraron que todas las muestras de agua se encontraron altamente contaminadas durante el mes posterior al monzón con valores medios de coliformes totales en 1129.52 ± 970.28 conteos / 100 mL y *E. coli* en 22.37 ± 11.74 conteos / 100 mL respectivamente. Se encontró que la tasa de prevalencia puntual de diarrea entre todos los niños era la más alta, es decir, el 45 por ciento de cada cinco enfermedades. Además, se encontró que el total de casos de población infantil afectada por enfermedades relacionadas con el agua se correlacionó negativamente con varios factores sociales y ambientales. Los servicios de salud pública para el tratamiento médico solo fueron preferidos por el 26 por ciento de los habitantes de los barrios marginales debido a la existencia de diversas barreras.

Palabras clave: Salud Infantil; Análisis bacteriológico; Servicio de salud pública; Enfermedades de transmisión por agua; Factores socioeconómicos

INTRODUCTION

Water is a necessary element for life. The provision of safe drinkable water is a precondition for a healthy living and thus provides immunity to fight against poverty, hunger and deaths. The Millennium Development Goals, pledged to reduce by half the proportion of people without access to safe drinking water (Wagstaff & Claeson 2004). Out of total water availability on earth, only 3 percent is freshwater and out of which only 0.01 percent of the total freshwater has been offered for human use (Hinrichsen & Tacio 2002). Even this little proportion of freshwater is under immense pressure due to various factors such as population growth, urbanization and huge consumption of water in trade and agriculture sector. As per the UNO report, the human population on the planet is increasing exponentially while the availability of freshwater is declining enormously. Several countries of Middle East, Africa and South Asia will have serious threats of water shortage within next 20 years.

In developing countries the problem is further aggravated due to the lack of proper management, unavailability of professionals and financial constraint (Ahmed et al. 2015). The quality of drinking water is directly associated with human health and indicates the effectiveness of environmental protection measures (Chung et al. 2009). According to Kovacs, integration of various environmental factors contributes to the pollution of surface water bodies (Kovacs et al. 1986). Not only discharge of industrial effluents and accidental spills, issues such as deforestation, urbanization, intensification in agriculture and non-point sources are also aggravating this problem.

More than a billion people do not have access to safe drinking water and well over 2 billion people live without adequate sanitation. The number of persons in urban areas of the developing countries with no access to safe drinking water increases sharply due to rapid urbanization mainly in peri-urban and slum areas since the last decade (WHO 2010). According to the World Health Organization report, due to unsafe drinking water and poor sanitation in most of the developing countries, the child population of those countries are the major sufferers due to occurrence of various diseases linked to it (WHO 2019).

Dehradun city, the largest and the capital city of the western Himalayan state of Uttarakhand is among such which has grown four fold in the last decades. With the rapid urbanization, however these cities are inviting many social and environmental problems due to increasing burden of the rising population. The major living sites for the urban poor in Dehradun city are slums which are mainly found along the Rispana and Bindal River. Out of the total city population, almost 25 percent of the population lives in slum areas. There are

129 notified slums as per the 2011 Census (Census of India 2011). Due to pathogen prone surroundings, with cramped conditions in shacks and with limited access to civic services such as safe drinking water supply, sanitary toilets and waste disposal facilities, these urban poor belongs to the major sufferer group from the urban society (Hardoy & Satterthwaite 1991). For children, the chances of survival dwindle in the absence of safe drinking water. Everyday almost 6,000 children dies due to water borne diseases. Young children are the first to get sick and die from water borne related illnesses- including diarrhoeal diseases (UNICEF 2014).

The increasing pollution of drinking water sources in Dehradun and the consequent effects on human health issues is of great concern. This review aims at highlighting the problem of water quality in five slums of Dehradun city with special emphasis on Total Coliform and E.coli and related health impacts on the child population in the form of various water related diseases. The water provided by the Uttarakhand Jal Sansthan through the pipelines is the main source of drinking water therefore we concentrate only on surface water. Furthermore based on the age classification of children of the slum dwellers, various links has been established between total number of children affected by the water borne disease and various social and environmental related factors prevailing out there. Also a study has been carried out based on the perception of slum dwellers regarding accessibility to public health services and various barriers to it.

MATERIAL AND METHODS

Site Selection: Five settlements of urban poor representing slums, as mentioned in (Table 1), were chosen under this study based on three criteria: near to the City Centre, along Untenable Site and near to the Fringe Area of the city (Figure 1). Bhagat Singh Colony and New Khurbura are located close to the city center and among them Khurbura is the oldest mohalla of Dehradun city. Rajeev Nagar and Deep Nagar are situated along the Rispana River thus acts as an untenable slum sites. Indira Nagar Colony slum is situated close to the fringe area of the city. A total of 150 households was randomly selected for the pilot study and out of which the sample households in each slum has been selected in same proportion as out of their actual households.

Data Collection and Indicators Used: Firstly during the month of May (pre monsoon) and August (post monsoon) some bacteriological analysis of the drinking water was performed for which three samples from each slum for particular month was collected in sterilized bottles and tested in government certified laboratory. A total of 30 drinking water samples was

collected randomly from point of use. All the sampling procedures were carried out according to the guidelines prescribed by Standard Methods for Examination of Water and Wastewater (APHA 2017).
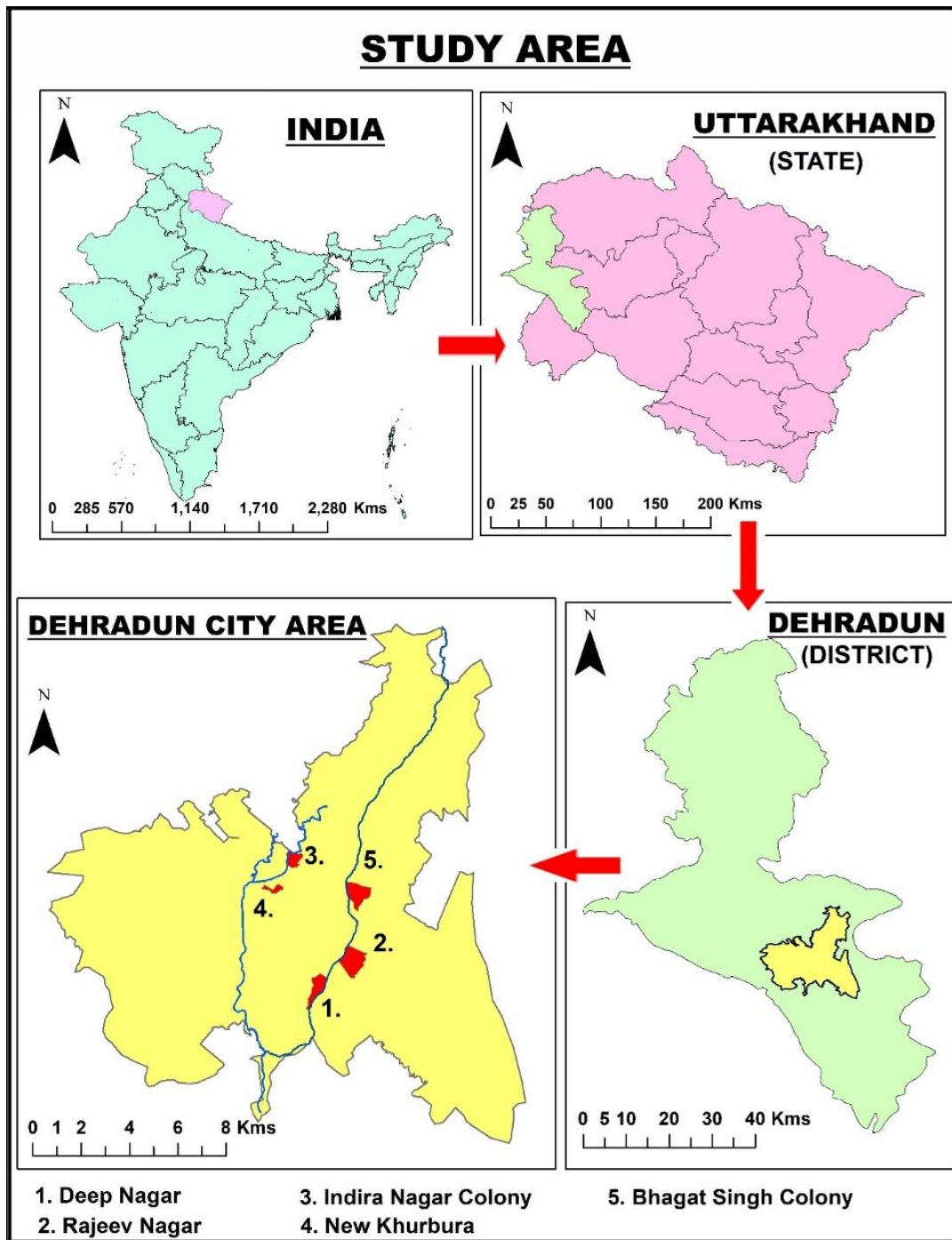

Figure 1: Selected slum sites for the study in Dehradun city area

Table 1: Details on settlement size and sample households

Settlement	Total Households	Sample Households
Deep Nagar	2123	39
Rajeev Nagar	2839	52
Indira Nagar Colony (INC)	1230	23
New Khurbura	1297	24
Bhagat Singh Colony (BSC)	670	12

Secondly during the month of August (post monsoon) a survey has been carried out for 150 households. Purposive selection of houses were performed with one consideration i.e. there must be atleast one children per household belonging to the age group of 0 to 5 years. The questions was organized and divided into so as to get information on some broad perspectives such as socio-economic, infrastructure, prevalence of water borne diseases among children and accessibility to public health care services. Data obtained through survey were analyzed using Microsoft Excel for descriptive statistical analysis and drinking water samples laboratory results was analyzed using Most Probable Number (MPN) Technique.

RESULTS AND DISCUSSION

Status of Drinking Water Contamination during Pre and Post Monsoon: Drinking water samples from point of use were analyzed for the presence of Total Coliforms and E. coli. According to the guideline values for the bacteriological quality of drinking water by the World Health Organization, all water intended for drinking must not be detectable in any 100 mL sample with Total Coliform Bacteria and E. coli (WHO 2017). The results revealed higher MPN per 100 mL samples in case of Total Coliforms and E.coli which indicates for the high fecal contamination in the water supply lines. During the pre-monsoon days, the mean value for the Total Coliform present was 174.8 per 100 mL with the standard deviation of 112.3 but these values increased enormously during the post monsoon days i.e. 1129.5 per 100 mL with the deviation of 970.3.

The risk of contracting water borne illness increased due to high values in post monsoon month. Total Coliform with highest recorded value of 2260.9 per 100 mL was found in Indira Nagar Colony during post monsoon days only as shown in (Table 2). The E.coli mean values for the pre monsoon days was found to be 18.9 per 100 mL. For post monsoon days

the mean value for *E.coli* also increased considerably i.e. 22.4 per 100 mL with the standard deviation of 11.7. From the results it can be derived that the highest of all the recorded values in case of Total Coliform and *E.coli* was found in post monsoon days. As we know Children are more susceptible than adults to the action of bacteriological toxicants, thus it became very important from health point of view especially for the children belonging to 0-5 age group.

Table 2: Water quality at point of use at different slum locations (as of may and august)

Slum	Water Contamination Indicator			
	Average Total Coliforms		Average *E.coli*	
	Pre	Post	Pre	Post
Deep Nagar	326.6	2210.7	17.25	10.55
Rajeev Nagar	59.25	227.5	1.1	17.35
Indira Nagar Colony (INC)	284.2	2260.9	1.9	30.7
New Khurbura	97.5	625.8	57.7	38.75
Bhagat Singh Colony (BSC)	106.6	322.8	16.6	14.5
	174.8±112.3	1129.5±970.3	18.9±20.7	22.4±11.7

Source: Water Testing Results from the Laboratory

Water Borne Diseases among Children: A poor water supply impacts health by causing acute infectious disease episodes. The quality of water related to the pathogens and bacteriological constituents in water that can give rise to both diarrheal and non-diarrheal diseases. As the health status of children aged 0-5 years portrays the overall impact due to any of social impairments (income, literacy, filtration knowledge) and environmental impairments (surrounding area, physical location, house type) pertaining to the society, we collected information on prevalence rate of selected water borne diseases and total number of cases affected by water related diseases was correlated with various factors. Out of total 150 households surveyed, 180 children was found between the age of 0-5 years and among them 150 was found to be severely sick. On an average one children per household was found ill. 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 for the illness that may have caused any deviations from the real situation. Nevertheless, result obtained, in gross, seems adequate enough to reveal

the type of water borne diseases and the contributing factors impacting the health of the children.

Prevalence of water-related diseases: In order to take account of seasonal impact on the occurrence of water-borne diseases, we considered point prevalence rate of six diseases that were commonly found. The details of diseases incidence and there prevalence rate per 1000 population of children is presented in (Table 3). Out of 150 households, 150 children of 0-5 years of age was found ill. The number of Diarrheal cases among the children was maximum in all the sampled slums. Out of total, 45 percent of the children was suffering from Diarrhea. 19 percent of children was found ill due to Gastroenteritis. Typhoid affected only 7 percent of children which was least in number.

Table 3: Prevalence rate of six water-borne diseases

Diseases	Cases per 1000 Population of Children				
	Deep Nagar	Rajeev Nagar	Indira Nagar Colony	New Khurbura	Bhagat Singh Colony
Diarrhea	404	386	367	357	278
Gastroenteritis	106	175	200	214	111
Jaundice	106	123	33	71	111
UTI	106	88	67	71	56
Dysentery	64	70	67	71	56
Typhoid	43	70	33	71	56

Factors Affecting Water Related Disease Burden among Children: Diseases directly related to water contributes significantly in the diseases burden worldwide. The children population in slum is at significant risk of water-borne diseases. There are various factors which leads to higher water borne diseased burden among children. A matrix of Pearson correlation coefficients is set up in order to examine the inter-relationships of various factors such as age wise total number of cases affected by water borne diseases compared with factors of social impairment (literacy of parents, family income levels and water filtering process) (Table 4) and environmental impairment (area surrounding the slum, physical location of slum) (Table 4). Correlation coefficients reveal that it is not only one but many factors that are causing higher number of water related disease burden. The Literacy of parents, family income levels and filtering processes adopted by families to filter drinking water in slums: physical location of slum, surrounding area and type of house, all are negatively correlated with the registered number of cases with water borne disease and is

shown in (Table 4). Majorly Low income levels of the families, poor or no drinking water filtration process adopted by the families having children and the surrounding areas are affecting the most.

Table 4: Pearson's correlation coefficient matrix of some social and environmental factors

Social factors				
Variables	Cases of Water Borne Diseases	Literacy of Parents	Income Levels	Filtering Process
Cases of water borne Diseases	1			
Literacy of Parents	-0.194	1		
Income Level	-0.726	0.667	1	
Filtering Process	-0.726	0.667	0.987	1
Environmental factors				
Variables	Cases of Water Borne Diseases	Physical Location	Surrounding Area	Type of House
Cases of water borne Diseases	1			
Physical Location	-0.194	1		
Surrounding Area	-0.652	0.408	1	
Type of House	-0.581	0.167	0.612	1

Access to Public Health Curative Service among Slum Dwellers: Millions of children dies from treatable conditions in most of the developing countries such as India. Three diseases (all preventable and treatable)—diarrhea, pneumonia, and malaria—are responsible for 52% of child deaths worldwide (Wagstaff & Claeson 2004). Child deaths can be reduced by 63% only if coverage rates of effective prevention and treatment interventions were to increase from current levels to 99% (Jones et al.2003). If we go by demand side, factors like cultural and educational may obscure the recognition of illness and the benefits from health care, while economic factors may suppress utilization and benefits if recognized. Unavailability of appropriate health services especially in the urban slums of our country could be treated as a factor for the supply side. The study endeavored to study the perception of slum dwellers regarding the accessibility and barriers to public health services when the children in their family fells sick.

Treatment Seeking Behavior: During the survey, it was found that majority of families whose children was found sick preferred non-governmental sources for the treatment as shown in (Table 5). Out of total 150 families, only 39 families (26 percent) had gone to

government hospital and government dispensary for the treatment. Private clinic, hospitals and drug stores were the most preferred source for medical treatment. Contrary to expectations, 23 percent of families sought treatment from alternative systems of medicine such as homeopath or other traditional healers.

Table 5: Treatment seeking behavior among slum dwellers

Place of Last Treatment	Frequency	Percentage
Govt. Hospital	28	18.7
Govt. Dispensary	11	07
Private Hospital	18	12
Private Clinic	36	24
Hakim/ Homeopath	24	16
Traditional Healer	10	07
Drug Store	23	15.3
	150	100

Satisfaction with the Public Health Services: Most of the families living in slums were dissatisfied with the health facilities provided by the government in comparison to private facilities as shown in (Table 6). 19.82 percent of the families were dissatisfied with the private health facilities whereas 38.46 percent of families were dissatisfied with the government health facilities.

Table 6: Level of satisfaction with the public health facilities among slum dwellers

Place of Last Treatment	Satisfied (%)	Not Satisfied (%)	Total (%)
Government	24 (61.54)	15 (38.46)	39 (100)
Private	89 (80.18)	22 (19.82)	111 (100)
Total	113 (73.33)	37 (24.67)	150 (100)

Various Barriers in Accessibility to Public Health Services: Large number of slum dweller families were dissatisfied with the public health facilities and there existed various reasons which are shown in (Table 7). The most common barrier were too long waiting time

and poor quality of care at the public health centers. Too long waiting time causes daily wagers to loss there wages due to longer time spent in hospitals. Also because of longer distances from residences to government hospitals, cost of transportation became a major barrier. Various other reasons such as rude behavior of staff in government hospitals, affordability and absence of health personals during the time of visit were other barriers which were forcing people to get some other options for the treatment of their children. There was large number of people among the slum dwellers dissatisfied with the public health curative services.

Table 7: Barriers to access to public health facilities as perceived by slum dwellers

Reasons for Dissatisfaction	Percentage
Waiting Time Too Long	38
Affordability	6.2
Poor Quality of Care	22
Distance	18
Absence of Health Personals	3
Rude Behavior of Staff	12.8

As conclusions, we know safe drinking water is essential for children to survive, to be healthy and for the overall development in terms of both physically and mentally. Study conducted in the slums of Dehradun City showed significantly higher values of Total Coliforms and E.coli during pre and post monsoon months and thus higher incidence of water related diseases was found among children of slum dwellers during post monsoon month. The higher number of water related diseased children aggravated due to number of factors like lower literacy of parents, lower family income levels, minimal or no knowledge about filtration process of drinking water, location of slums (along nallah, along other drains), surrounding area (commercial, railway/ other and institutional) and type of house (Kaccha, semi pakka and pakka). All factors were negatively correlated with the total number of children suffering from water related diseases. In spite of these factors a perception study has been carried out to emphasize the difficulties in accessing the public health curative facilities faced by the population of slum areas. It was found that larger sections of the slum dwellers were not satisfied with the government health institutions due to various reasons. The girth of the problem lies on the fact that Dehradun city population size is expanding rapidly and also slum settlers are rising in numbers. 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 facilities in the slums and effective health care facilities for the slum dwellers seems among major issues of immediate concern for reducing the burden of such diseases among children. Also coordinated efforts among various departments such as water supply department, health department and enforcement department can be encouraged and will play a vital role in addressing the ongoing problems.

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REFERENCES

Ahmed, T., Imdad, S., & Butt. N.M. (2015). Bacteriological assessment of drinking water of Islamabad Capital Territory, Pakistan. *Desalination and Water Treatment*, 56 (9), 2316-2322. doi: 10.1080/19443994.2014.963154

American Public Health Association (APHA). (2017). Standard Methods for the Examination of Water and Wastewater. 23rd Edition. Washington DC.

Census of India. (2011). District Census Handbook- Dehradun. Government of India, New Delhi.

Chung, P.L., Chung, C.Y., Liao, S.W., & Miaw, C.L. (2009). Assessment of the school drinking water supply and the water quality in Pingtung County, Taiwan. *Environ Monit Assess*, 159(1-4), 207-216. doi: 10.1007/s10661-008-0623-9

Hardoy, J.E., & Satterthwaite, D. (1991). Environmental Problems of third world cities; A global issue ignored?. *Public Administration and Development*, 11, 341-361. https://doi.org/10.1002/pad.4230110405

Hinrichsen, D. & Tacio, H. (2002). The coming freshwater crisis is already here. Finding the Source. *The Linkages between Population and Water*, Woodrow Wilson International Center for Scholars, Washington, D.C.: ESCP Publication, 1-26.

Jones, G., Steketee, R.W., Black, R.E., Bhutta, Z.A., Morris, S.S. (2003). How many child deaths can we prevent this year?. *Bellagio Child Survival Study Group, the Lancent,* 362 (9377), 65-71. doi:10.1016/S0140-6736(03)13811-1 66-71.

Kovacs, G., Vlachos, E., Webb, A., & Murphy I., (Eds.). (1986). Decision support systems for managing large international rivers. *The Management of International River Basin Conflicts*, George Washington University, Washington, D.C., 132–133.

UNICEF. (2014). The State of the World's Children 2014 In Numbers: Every Child Counts: Revealing disparities, advancing children's right. New York, USA. www.unicef.org/sowc2014/numbers

Wagstaff, A., & Claeson, M. (2004). The millennium development goals for health: Rising to the challenges. Washington, D.C.: World Bank.

World Health Organization (WHO). (2010). Monitoring Water and Sanitation: For Evidence-Based Policy and Interventions. *Department of Public Health and Environment.* WHO, Geneva, Switzerland.

World Health Organization (WHO). (2017). Guidelines for drinking-water quality: fourth edition incorporating the first addendum. *Department of Public Health and Environment*. WHO, Geneva, Switzerland.

World Health Organization (WHO). (2019). Water, Sanitation, and Hygiene in Health Care Facilities. *Department of Public Health and Environment.* WHO, Geneva, Switzerland.