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Evaluation of Drinking Water Quality From Panchganga River Basin During Pre and Post Flood Period

KEYWORDS: Panchganga River, Flood, Drinking Water Quality.

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ABSTRACT *The effect of floods on drinking water quality at seven sites in Panchganga river basin was investigated by studying five parameters namely pH, Turbidity, Hardness, TDS, and MPN, during pre and post-flood period in year 2011. Pre-flood samples from five sites and post-flood samples from all the seven sites did not meet the BIS standard for safe drinking water in terms of MPN. In addition, samples from three sites did not satisfy the standard in terms of turbidity in post-flood period. The values of Turbidity and MPN drastically increased (up to 84% and 121%, respectively) from their pre-flood levels, which was attributed to the runoff from the basin entering into the river during floods. The government agencies found it difficult to provide safe drinking water in the aftermath of floods.*

1. Introduction:

Among the various needs of water, the most essential need is for drinking. Drinking water and sewerage services are vital in ensuring the health and well-being of populations and as such fulfill a central role in the development process. According to the World Health Organization (WHO, 1998) in disaster like situations, these basic services are imperative for the rapid return to normalcy. The impact of a natural disaster like flood can cause contamination of water through surface runoff in addition to breaks in supply pipelines, damage to structures, water shortages, and collapse of the entire system. Deterioration of drinking water quality also arises from introduction of chemical compounds into the water supply system through leaks and cross connection.

Mosley et. al., (2004) studied effects of a tropical cyclone on the drinking water quality of a remote Pacific Island, and reported that natural disasters can greatly magnify the burden of illness associated with inadequate water resources. Flooding is the second most common type of natural disaster after windstorms, but it affects a larger geographic area and population than any other catastrophe. During floods, water sources, especially unprotected wells and surface water sources, become contaminated with industrial, human and animal waste. In general, epidemic disease need not have frequent occurrence after natural disasters, but in the developing world, high rates of morbidity and mortality can result from common illnesses under these crisis conditions.

1.1 Study area

The study area was located in Kolhapur district (15° 43′ and 17° 17′ North latitude and 73° 40′ and 74° 42′ East longitude) on the eastern side of Western Ghats region in south Maharashtra. The area of the district is 7746 sq. km., forming 2.5% of the state area with 12 tahsils in the district. The climate is temperate and the annual temperature ranges from 10^0C to 35^0C. The district receives average annual precipitation of 1019.5 mm with 65 normal rainy days, out of which precipitation of 809 mm during SW monsoon (June to September) is received in 54 rainy days. As per Census 2011 Kolhapur, district population was 38,74,015 (Town Planning Department Kolhapur, 2013). Panchganga river, formed by the five tributaries originating in the Western Ghats, flows for 136 km through Kolhapur district as a major tributary of river Krishna before their confluence at Narasinghwadi. A large population living along Panchganga and in the basin heavily depends on the river for their livelihood and domestic needs, particularly drinking water supply. In the recent years, the river is increasingly polluted due to domestic sewage and industrial effluents (Mulani et. al., 2009).

Often eastern part of Kolhapur district is affected by annual floods. Especially Karveer, Hatkanangale and Shirol tahsils in lower Panchganga river basin face devastating effects of floods. The negative effects of flood were due to bacteria and pathogens carried by contaminated soil, sewage and solid waste into rivers and streams, ultimately entering the drinking water supply network. The inadequately treated water transferred contamination through the damaged water supply system, further aggravating the situation. This posed a great risk for human health as these river water supplies were used for drinking purposes without further treatment. This is also endorsed in the health statistics that patients suffering from waterborne diseases during monsoon period mainly like Jaundice, Diarrhea, Dysentery, and Gastro in the isolation hospital were over 545 (Kolhapur Municipal Corporation (KMC), 2009).

2. Materials and methods

The impact of floods on drinking water quality in Panchganga river was studied during monsoon i.e. pre and post flood period in year 2011. Sample collection was done at seven-selected field locations from upstream, midstream and downstream, as shown in table 1.

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Table 1. Location of drinking water sampling sites along Panchganga river

Sr. No.	Name of Sampling Site	Site code	Type of habitation	Location	MSL Meters
1.	Prayag Chikhalil, tahsil.- Karveer	(S1)	Village	Up Stream	545
2.	Shukrawar Peth, Kolhapur tahsil.- Karveer	(S2)	City	Mid-stream	566
3.	Kasba Bawda , Kolhapur tahsil.- Karveer	(S3)	City	Mid-stream	553
4.	Rukadi, village tahsil.- Hatkanangale	(S4)	Village	Down-stream	562
5.	Rui , tahsil.- Hatkanangale	(S5)	Village	Down-stream	553
6.	Ichalkarnji City tahsil.- -Hatkanangale	(S6)	City	Down-stream	571
7.	Kurundwad town tahsil.- -Shirol	(S7)	Town	Down-stream	537

The study sites were selected on the basis of type of habitation i.e. village, town and cities from upstream, midstream and downstream portion of Panchganga river in Kolhapur district (Table 1). The drinking water samples were collected from supply sources and not directly from floodwaters. As per site selection out of the seven sampling sites, three each were from village, city, and one from town.

The Prayag Chikhali village (S1) was located near origin of Panchganga River i.e. at confluence of five tributaries namely Dhamani, Kumbhi, Kasari, Tulsi and Bhogavati. Village grampanchayat supplies treated piped drinking water after lifting raw river water. Kolhapur city is downstream of site S1 where sites (S2) and (S3) were located in midstream. Kolhapur Municipals Corporation supplied treated piped water, from two water treatment stations. The flood is expanded in the downstream portion of the river where sites (S4) and (S5) were located, where piped water was supplied by the respective Grampanchayats. The site (S6) was near industrial city also located in downstream of the river having its own treated piped water supply system. The site (S7), where piped water supplies were provided by the Nagar panchayat, was at the confluence of Krishna and Panchganga rivers.

The water samples were collected during pre-flood and post-flood period at the field sites and were later analyzed at the earliest for the five selected physico-chemical and bacteriological parameters such as pH, total dissolved solids (TDS), hardness, turbidity and MPN per 100 ml., by the methods described in American Public Health Association, (APHA, 1998). The objective of the study was to evaluate changes in the drinking water quality in Panchganga river basin during pre and post flood period.

3. Results and discussion

During Panchganga river floods, affected people in the district repeatedly face safe drinking water scarcity crisis. The urban and semi urban population, despite being supplied with treated drinking water, also get affected due to poor water quality during floods causing a concern Values of the five drinking water quality parameters during pre-flood and post-flood period, from the water samples collected at seven sites along Panchganga River, are shown in the table 2 and table 3 respectively.

Table 2.Values of the five drinking water quality parameters from the study sites along Panchganga during pre-flood period in year 2011

Sr. No.	Sample site	pH	TDS mg/lit	Hardness mg/lit	Turbidity NTU	MPN per 100 ml
1	(S1)	7.5	123	45	1.2	0
2	(S2)	7.5	127	65	1.5	0
3	(S3)	7.6	150	73	1.8	2
4	(S4)	7.7	170	77	2.0	4
5	(S5)	7.8	182	83	2.8	6
6	(S6)	7.8	199	94	3.3	11
7	(S7)	7.6	179	79	2.2	5
	Average	7.6	161	74	2.1	4
	Maximum	7.8	199	94	3.3	11
	Minimum	7.5	123	45	1.2	0
	Standard deviation (S.D.)	0.13	28.89	15.48	0.73	3.87
	BIS Standards	6.5-8.5	500	300	5	0

The table 2 shows the drinking water quality values (i.e. maximum, minimum, average S,D. and BIS standard) for the five parameters studied. The average values are for pH 7.6 (± 0.13), total dissolved solids (TDS) 161 mg/lit (± 28.89), hardness 74 mg/lit (± 15.48), turbidity 2.1 NTU (± 0.73), and MPN 4 per 100 ml (± 3.87). _An individual trend of gradual increase was observed in values of the five parameters from upstream to downstream ~~in the river~~, attributed to increasing discharge of pollutants in the river from upstream to downstream. Eventually this is reflected in pollution level of drinking water supplies through lift irrigation schemes to towns and villages. However, due to primary treatment at the water distribution level all the values of the parameters, except MPN value, were within the BIS Standards. The MPN values upstream, at both the sites (S1) and (S2) revealed 0 per 100 ml MPN. However, microbial contamination was noticed, at the remaining five sampling sites from site (S3) and downstream, even before the flood event all along Panchganga river basin.

Table 3. Values of the five parameters drinking water quality from the seven field sites in Panchganga River during post- flood period in the year 2011

Sr. No.	Sample site	pH	TDS mg/lit	Hardness mg/lit	Turbidity NTU	MPN per 100 ml
1	PrayagChikhali (S1)	7.6	211	51	1.8	2
2	Shukrawar Peth (S2)	7.7	223	71	2.7	2
3	Kasba Bawda (S3)	7.7	250	79	2.9	4
4	Rukadi (S4)	7.8	265	82	4.1	8
5	Rui (S5)	7.9	277	101	5.2	11
6	Ichalkarnji (S6)	7.9	300	118	5.5	25

Sr. No.	Sample site	pH	TDS mg/ lit	Hard-ness mg/lit	Turbid-ity NTU	MPN per 100 ml
7	Kurundwad (S7)	7.7	280	87	5.1	10
	Average	7.8	258	84	4.0	9
	Maximum	7.9	300	118	5.5	25
	Minimum	7.6	211	51	1.8	2
	Standard de-viation	0.11	32	21.37	1.45	8.00
	BIS Standards	6.5-8.5	500	300	5	0

It can be seen from Table 3 that in the post flood period the average pH value 7.8 (±.11) at the study sites, ranged from 7.6 to 7.9, which was within the BIS Standards i.e. 6.5-8.5, indicating slight increase in the pH due to flood. As per the study results, during post flood period TDS values averaged 258 mg/l (±.32) and ranged between 211 to 300 mg/l. Compare to the pre-flood period, in post flood period all of the sites reported higher TDS values as expected. Nevertheless, all these values were well within the desirable BIS standard of 500 mg/l. Among the study sites, Ichalkarnji site (S6) reported highest value of 300 mg/l during post flood period. The increase in TDS value in drinking water was attributed to large amount of dissolved salts reaching river waters through domestic waste, untreated sewage as well as Industrial waste as non-point pollution from the catchment area.

Hardness of river water during post flood period in the study area was an average of 84 mg/l (±.21.37), which varied from 51 to 118 mg/l respectively at different locations. Among the sampling sites on downstream of river (S5) and (S6), as compared to other sites showed higher Hardness values in post flood period. However, all values, during pre and post flood period at the seven sites, were within desirable BIS standards.

Allen et. al., (2008) in the report of the Health Ministry of British Columbia, Canada stated that turbidity in water is due to suspended and colloidal particles, such as clay, silt, organic and inorganic tiny divided matter, plankton and other microorganisms. During the present study, it was observed that there was increase in Turbidity value from site (S1) to site (S7) i.e. from upstream to downstream all along Panchganga river during post-flood period. Turbidity at site (S1), (S2), site (S3), and site (S4) showed increasing trend as compared to their pre flood period values. Whereas the turbidity only at sites (S5), (S6) and (S7) showed values above the desirable standards of 5 NTU as per BIS.

According to Russek and Colwell, (1983) the most-probable-number (MPN) method is an important technique in the enumeration of viable bacteria in samples of food, water, and natural products. During the present study, the highest MPN level was recorded at site Ichalkaranji city site (S6) in post flood periods i.e. 25 per 100 ml. It was revealed that during post flood seasons MPN values in samples from all sites were positive, and were also higher than that of the BIS desirable standards (fig 1).

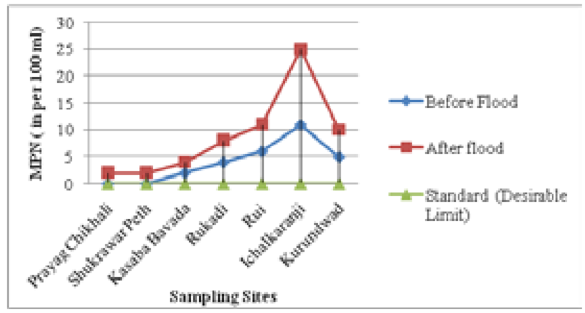

Figure 1. Comparison of MPN value per 100 ml during pre-flood and post flood period in Panchganga river

Apparently during the investigation, the microbial pollution took place when the contaminated surface runoff from land mixed up with the floodwater, eventually entering the drinking water supply through intake wells, leakages or flooding. It is common that natural disaster's impact can cause water contamination, pipelines breaks, structural damages, water shortages, and or collapse of the entire system (WHO, 1998). Nakade (2013) reported presence of 'Salmonella' especially in the month of July 2010 and August 2010 and 'Shigella' was detected in water samples from Kolhapur city in the month of July 2010. According to World Health Organization (WHO) and Organization for Economic Cooperation and Development (OECD), (2003) the microbial quality of drinking water is a concern to consumers, water suppliers, regulators and public health authorizes alike. The potential of drinking water to transport microbial pathogens to many people, causing subsequent illness, is well documented in countries at all levels of economic development.

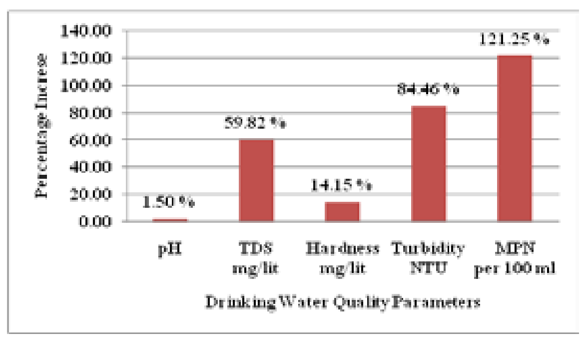

Figure 2.Percentage change in drinking water quality parameter values between pre-flood and post flood period in the year 2011

The change in the values of the five parameters in drinking water, from the seven sampling sites, during pre-floods and post flood period in 2011 are summarized in the figure (Fig.2). The figure shows percentage increase in all the parameter values in the post flood season. However, minimum increase was reported in pH, and modest increase hardness values. Considerable increase was recorded in total dissolved solids (TDS), turbidity and MPN values in the drinking water samples.

4. Conclusion

Schuster-Wallace et. al., (2008), while working in Canada observed that increased frequency and magnitude of flood events affected not only availability of clean water, but chemical storage and sewage facilities, compromising quality. Some of this was also noticed during the floods in the study area. According to UNESCO (2011), more intense rainfall is expected to lead to a deterioration of water quality since it enhances the transport of pathogens and other dissolved pollutants to surface water and groundwater. More frequent heavy rainfall overloads the capacity of sewer systems, and wastewater treatment plants. Study by Lomate, (2002) showed that the raw water source of Kolhapur city, particularly from river Panchganga, was of poor quality. Water collected from different service reservoirs in the city during the study showed deterioration in its chemical and bacteriological quality. Mainly frequent linkages from supply pipeline lead to water wastage and back suction of sewage and pollution causing contamination of drinking water. Impact of these conditions aggravate further during flooding. In another study on water quality in Kolhapur city Loni and Raut, (2012) concluded that majority of the population from Karveer tahsil in Kolhapur district depends on river Panchganga for their drinking water requirement and domestic needs.

In the present study besides increase in the values of studied parameters in drinking water samples during floods, it is a serious concern that samples at all sampling sites revealed presence of MPN, which exceed the BIS (2004-05) drinking water standards. Clasen and Smith, (2005), studied the drinking water response to the Indian Ocean tsunami including the role of household water treatment and reported that post-flood increases in cholera, cryptosporidiosis, non-specific diarrhea, poliomyelitis, rotavirus, typhoid and paratyphoid, and a variety of vector-borne diseases.

The results revealed that turbidity values (post flood) in three sites surpass the BIS standards, where as site S6 showed higher levels among all the sites. This indicated that water quality in downstream area was more affected during floods._In general, Ichalkarnaji i.e. Site (S6) showed highest level values of all the parameters during post flood period suggesting it as site with most polluted drinking water in the Panchganga river basin. In addition to the lack of availability of adequate quantity of clean drinking water, the available contaminated water poses threat to health of the flood-affected people. Probable reasons for this contamination are improper drainage pattern, waste disposal and lack of sanitation facility in the towns and villages along the river.

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