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Evaluation of Water Quality of Panchganga River with reference to Waterborne Diseases

Environmental Science

KEYWORDS : River pollution, Waterborne Diseases, Water Quality Index, and Health Survey.

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ABSTRACT

In Kolhapur District in Maharashtra water pollution due to domestic and industrial sources has lately been causing various waterborne diseases amongst the people living in Panchganga river basin. During this study Panchganga river water was analyzed, in three seasons during years 2010-2012, for nine physico-chemical parameters. MPN count of drinking water and questioner survey of locals was also carried out to understand the possible correlation between the river water quality and water-borne diseases incidence amongst the locals. The waterborne diseases observed in the study area were Gastro, Hepatitis, and Fever 6 etc. Water Quality Index (WQI) was carried out to know the status of Panchganga river water and MPN count was studied to recognize the extent of fecal contamination in drinking water at respective sites. The status of water borne diseases in the study area was further evaluated by administering a questionnaire survey. It is observed that, except few values of water quality index, the rest are found to be less than 50, indicating unacceptable quality of water from Panchganga River. This condition could be related to increasing trend of number of people suffering from water borne diseases during 2010-2012.

Introduction

Water pollution is the main cause of a number of waterborne diseases world over, particularly in the developing countries. Polluted water not only affects the life of present generation but it also affects the life of upcoming generations because of its long-lasting effects. According to Garg (2012) in India alone nearly 40000 persons had consumed this contaminated water over the past 14 to 20 years. Incidence of cancers, birth defects and diseases related to skin, lungs, brain, kidneys and liver are several times more prevalent in the communities than anywhere else in the India. Kolhapur district is privileged to be located in the eco-sensitive Western Ghats which is an origin of several streams and rivers. Panchganga River does not originate in the hills but is formed in the midstream portion by five tributary rivers, and beyond the confluence at Prayag downstream it is considered as Panchganga River. The river drainage has significant influence on the land use and socio-economic fabric of the district. Of late there is ever growing demand for the river water by the cash crops, urbanization and industrialization in the economically progressive region. The quality of the once pristine river is greatly deteriorated in the recent years and now has serious impact on health of the people in the river basin.

The present study deals with Panchganga river water quality due to growing incidence of domestic, agricultural and Industrial pollution which is causing environmental degradation in the river basin. Waterborne diseases, and associated health hazards among the population in Panchganga Basin have been reported for some time. Therefore by using Water Quality Index (WQI) that relates the health survey of the people in the study area along the banks of river Panchganga. This paper presents water quality data of river Panchganga during the period 2010 to 2012 and a health survey conducted in the study area to understand relationship between river water quality and water borne diseases in the study area.

It was observed that the river received heavy load of pollution from diverse sources, besides nonpoint pollution from the upper catchments. This was confirmed by the report of MPCB and Collector office, Kolhapur,(2009) on pollution in the river which received 160.94 million liter/day (MLD) domestic sewage without treatment, 18.59302 MLD of Industrial effluent, 9,00,000 liter/day hospital, OPDs and laboratory effluent, 4,90,000 liter/day effluent from servicing station, 2300 kg/day slaughter house waste, 2310 kg/day local fish and mutton market waste, and 18,21,700 liter/day of effluent from hotels and vendors. In addition there was 78427.53 tons/year of solid and 45560 liter/year of liquid agricultural waste. 527.93 tons/year 'nirmaly' waste from religious activities, 110461 Ganesh idol emersion, and 491.68 tons/year of ash from crematorium. On daily basis there was 35030 cattle washing/day, 2430 people bathing/day, cloth washing by 8000 persons/day, vehicle washing 342/day, 418.34 tons/day of domestic solid waste, 90.1 tons/day industrial waste, 663.15 kg/day biomedical waste, 800 kg/day servicing station waste and - 3278 kg/day waste from hotels/vendors.

2. Material and Methods

2.1 Study Area

The study area is in the northern part of Kolhapur district, located at $15^0$43' and 17^0 17' North latitude and $73^0$40' and $74^0$42' East longitude. The western part i.e. 2/3 of the district is located in the Western Ghats and all the five major tributaries of river Panchganga originate in the Sahyadri mountain range to the west, the area of the district is 7746 sq. km. and catchment of Panchganga river is 2099.63 sq. km. length of Panchganga river is 81 Km including the tributaries the Panchganga river is 338 km. As per 2011 census Kolhapur had a population of 38, 74,015 (Kolhapur District Tourism Plan, 2012). There are 9 K.T. weirs, across the river Radhanagari major and some medium and minor dams make it a perennial river.

The river basin lies between $16^0$19'04" to $16^0$55'19" North latitudes and $73^0$44'08" to $74^0$42'18" east longitude. Panchganga river has no true origin being formed at Prayag after the confluence of its five tributaries namely Bhogawati (83 km), Tulsi (30 km), Dhamni (41 km), Kumbhi (48 km) and Kasari (69 km), in its upper catchment, Panchganga river proper runs in the mid and lower catchment in its basin and runs from Prayag to Nrusinhwadi (81km) before confluence with river Krishna. There are 174 villages, 2 municipal towns (Ichalkarnji and Kurundwad) and one city (Kolhapur) situated on the bank of the river (Collector office, Kolhapur, 2009).

Total of five locations, based on local ecology and human impact, were selected for drinking water collection along Panchganga River in Kolhapur district as shown in table 1

Table 1 Location of Panchganga river water collection sites

Sr. No.	Drinking Water Sampling Sites	Site Code	Site Location	Mean Sea Level(MSL) in meter
1	Prayag Chikhalil, village, tahsil.- Karveer	(P1)	$16^0$44'10.3" N, $74^0$10'35.7" E	545
2	Panchganga Ghat ,Kolhapur city, tahsil.- Karveer	(P2)	16°42'32.1" N, 74°13'09.4" E	544
3	Rajaram K.T. weir, Bawda tahsil.- Karveer	(P3)	16°44'10.2" N, 74°14'09.2" E	543
4	Shiroli bridge, Shiroli village tahsil.- Karveer	(P4)	16°42'41.3" N, 74°17'01.3" E	542
5	Kurundwad Ghat, Kurundwad tahsil.- Shirol	(P5)	$16^0$31'22.2" N , 74^0 36' 30.1" E	533

The five sampling stations selected along Panchganga river were viz. Prayag Chikhali village near origin of Panchganga river at confluence with Kasari river, Panchganga Ghat, upstream of Kolhapur city, Rajaram K.T. weir at Kasba Bawda village midstream at Kolhapur city, Shiroli bridge downstream near Shiroli village, and Kurundwad Ghat, at Kurundwad town before confluence of Panchganga with river Krishna.

Major source of pollution at the site1 (P1) was from predominant sugarcane cultivation and sewage from the villages around. Site 2 (P2) was at Panchganga Ghat at Kolhapur city where municipal waste mixes with the river water through Dudhali and Jayanti nalas. The Site 3 (P3) was at Kasba Bawda village, and 8.90 km downstream of Site (P2), where sewage as well as sugar factory and distillery effluent mixed with river water. Site (P4) was near NH_4 Highway Bridge where Panchganga received industrial effluents from Shiroli MIDC and residential waste from nearby area. The sampling sites P2, P3 and P4 were located around boundaries of Kolhapur municipal limits. Site (P5) i.e. Kurundwad Ghat is situated just upstream of confluence of river Panchganga with river Krishna. All along its way, the stretch of river upstream of the site receives industrial effluents and sewage from Kala nalas in the industrialized township of Ichalkarnji and nearby villages namely Nrusinhwadi and Kurundwad. All along the stretch of the river, through its five tributaries various sources carry domestic waste, and industrial effluent, mainly from sugar industry and distillery units and textiles from industrial estate in Ichalkarnji town.

During the study raw water samples were collected at the selected sites and analyzed for the 9 water quality parameters viz. DO, Fecal coliform, pH, BOD, Temperature change, Total phosphate, Nitrates, Turbidity and Total solids as per standard procedures given for water analysis in APHA, (1998).

According to the book Field Manual for Water Quality Monitoring, (Water Research Centre, (2008), the National Sanitation Foundation surveyed 142 people representing a wide range of positions at the local, state, and national level about 35 water quality tests for possible inclusion in an index. Nine factors were chosen and some were judged more important than others, so a weighted mean is used to combine the values. So that field measurements could be converted to index values, respondents were asked by questionnaire to graph the level of water quality (0 through 100) corresponding to the field measurements (e.g., pH 2-12). The curves were then averaged and are thought to represent the best professional judgment of the respondents. When test results from fewer than all nine measurements are available, we preserve the relative weights for each factor and scale the total so that the range remains 0 to 100. Hence Water Quality Factors and Weights are Dissolved oxygen (0.17), Fecal coli form (0.16), pH (0.11), Biochemical oxygen demand (0.11), Temperature change (0.10), Total phosphate (0.10), Nitrates (0.10), Turbidity (0.08) and Total solids (0.07).

Water Quality Index (WQI) weightage and corresponding legends were considered such as Excellent (90-100), Good (70-90), Medium (50-70), Bad (25-50) and very Bad (0-25). The calculation of WQI was carried out using software of World Sanitation weighted arithmetic index method i.e. Keith Alcock's Water Quality Index, subsequently formulated using Keith Alcock's Java Script web master process (2008). It was expected that the investigation would give correlation between Panchganga river water quality and water born diseases in the study area. Simultaneously Most Probable number (MPN) was determined for drinking water at residential area near the five sites to calculate correlation between WQI of river water and MPN in drinking water.

Attempt was made to learn about the experience of the locals related to waterborne diseases and epidemics in Panchganga basin. The residents affected by epidemics were approached by interview schedule method. The respondents were selected by random sampling technique and a total of 65 respondents were interviewed. The three sites selected were based on their location in the river basin and accordingly number of respondent were upstream site Kolhapur city (25), Gandhinagar area midstream site (15) and Ichalkaranji city downstream site (25) in the river basin. In health survey information collected was regarding epidemics, diseases type, season of occurrence, frequency, problems associated with disease and cause of disease.

To understand the impacts of epidemics, information related to epidemics in Kolhapur district was collected for five-year period from 2008 to 2012. Emphasis was given in particular to status of the drinking water quality of different municipal wards in the Kolhapur city during year 2010. It was observed that during study Hepatitis was rampant in the Kolhapur city in 2011-12.

3. Result and Discussion

The epidemic related waterborne diseases were recorded in the Panchganga basin e.g. Fever 6 in Shiroli PU. (Madarasa) in February 10, Hepatitis (Rukadi) in February 10, Hepatitis (Rukadi) in February 11, Hepatitis (Nave Pargaon) in February 11, Hepatitis (Herwad) in April 11, Fever (Nerli) in April 12 and Hepatitis (Ichalkarnji) in April- May 2012 (Health department, Zilha Parishad, Kolhapur, 2013 and Health department, Ichalkarnji Municipal Corporation, 2012). There were numerous cases mainly of Gastro, Hepatitis and Fever in Kolhapur city especially in Months of April and May during the period (Health Department, Kolhapur Municipal Corporation, 2012).

Table 2.Water Quality Index (WQI) of Panchganga river water at the five sampling sites in years 2010 to 2012

Year	Season	P1	P2	P3	P4	P5	Average	Year Average
2010	Summer	49	48	45	41	46	45.80	48.60
	monsoon	54	53	51	46	49	50.60	
	Winter	55	51	48	44	49	49.40	
2011	Summer	47	45	42	40	43	43.40	45.67
	monsoon	52	49	47	44	47	47.80	
	Winter	49	47	45	42	46	45.80	
2012	Summer	44	42	40	37	42	41.00	42.93
	monsoon	50	46	43	39	45	44.60	
	Winter	48	45	42	39	42	43.20	

Note- Bold value indicate bad water quality

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From table 2 it is seen that except few values of water quality index most values reveal poor river water quality index, that is less than 50. The water quality index general trend suggests gradual decrease in quality of river water; which is related to increase in pollution level in Panchganga river. Among the sites, water at Prayag Chikhali (P1), upstream of Kolhapur city was least polluted where as Shiroli (P4) site represented with most polluted water sample, as it is downstream of Kolhapur city, and in addition surrounded by number of industries which discharge effluents into Panchganga river. It is not only the cities and big towns on river bank responsible for pollution as the Rural water supply Department, Zilha Parishad, Kolhapur (2009) has listed 174 villages along the river course to be responsible for pollution of the Panchganga river.

It can be seen from table 2, that except in monsoon of 2010, all average WQI of Panchganga river had bad quality i.e. less than 50 and in monsoon 2010 average water quality index was found to be slightly greater than 50. Overall observation discovered that Panchganga river water quality was bad during summer in the three years and it was slightly improved in monsoon and again declined in winter. From table no 2. It is obvious that Panchganga river pollution increased as the average water quality index showed that the values of average WQI was decreasing from 48.60 to 42.93 during the study period i.e.2010 to year 2012.

Change in the land use practices in the catchment, agricultural expansion up to and encroachments beyond river banks in the catchment, excess lifting of water for irrigation in the sensitive areas, excess use of agrochemicals, point and no-point pollution from the catchment, urbanization related problems, domestic waste, sewage, eutrophication, and weed infestation, are some of major the reasons for the qualitative and quantitative change in the character of vital resources in the Panchganga river system (Barik, 2000). The diverse human activities in the Western Ghats have drastically negatively influenced the natural water sources from their origin downstream, in addition to manipulating those causing almost permanent changes in the age-old and stabilized aquatic ecosystems (Samant, 1995). The values of the physio-chemical and biological parameters clearly show that the Panchganga river water quality deteriorates in the downstream direction. The high values of chlorides, sulphates, phosphates, and MPN are mainly caused by domestic sewage (Kulkarni, 1993). Shinde, (1992) has revealed the rapidly changing nature of the rather remote and neglected Panchganga river system from original pristine to highly degraded ecosystem. Pawar, (1988) revealed that there was a sudden decline in the quality and quantity in fish catch in the Panchganga river which was comparatively more drastic downstream due to the enhanced effect of pollution.

During the study MPN values of drinking water was studied at the five identified village sites in the seasons of summer, winter and monsoon. The MPN values in respective season at each site, seasonal average and annual average for the study year is given in the table no.3.

Table 3.MPN/100ml of drinking water at five village sites along Panchganga river

Year	Season	Prayag Chikhali	Panchganga Ghat	Rajaram K.T.Weir	Shiroli	Kurundwad	Season Average	Year Av.
2010	Summer	2	4	6	8	6	5.20	6.67
	monsoon	4	6	12	14	10	9.20	
	Winter	0	2	8	10	8	5.60	
2011	Summer	2	4	8	10	10	6.80	7.47
	monsoon	6	8	10	12	12	9.60	
	Winter	0	4	6	10	10	6.00	
2012	Summer	8	10	11	15	12	11.20	11.80
	monsoon	12	12	14	17	14	13.80	
	Winter	4	11	12	14	11	10.40	
	Average	**4.22**	**6.78**	**9.67**	**12.22**	**10.33**	**8.64**	

The MPN/100 ml values of drinking water sites were positive at all sites Panchganga river basin except in few cases during 2010 to 2012 in all seasons indicating drinking water contamination. In addition, the results revealed that MPN values increased from upstream to downstream, and also every successive year. At the upstream of the river the MPN values of drinking water were found to be around 4.2, then there was continuous increase in the values in downstream sites i.e. Panchganga Ghat (6.7), Rajaram Bandhara (9.7), and Shiroli (12.2). Lowering of this value (10.3) at Kurundwad can be attributed to dilution of river water at Krishna river confluence. The drinking water along downstream of the river Panchganga showed more MPN/100ml where more cases of epidemics were found, especially in the year 2012. Correlation between seasonal WQI and MPN values in drinking water from Panchganga river was attempted.

Table 4. Correlation between seasonal water quality index and MPN in drinking water in study sites in Panchganga basin

Sr. No.	Years	Seasons	Correlation	
1		2010	Summer	-0.94
2			Monsoon	-0.89
3			Winter	-0.93
4		2011	Summer	-0.91
5			Monsoon	-0.92
6			Winter	-0.82
7		2012	Summer	-0.91
8			Monsoon	-0.92
9			Winter	-0.92

Table 4 shows that there was very high negative correlation (i.e. nearly equal to the -1) between seasonal WQI and MPN in drinking water in the selected sites in Panchganga basin. This suggests that during the three seasons of year 2010, 2011 and 2012, decrease in WQI of river water was related to MPN count increase in drinking water in the study sites. This could be attributed to Panchganga river quality deteriorated by faecal contamination which is reflected in poor drinking water quality.

According to the survey most respondents (90.77%) experienced epidemics in the study area, nearly once or twice every year. it was also reported that among all the epidemics a majority (77.92%) diseases ware waterborne diseases. As compare to the upstream and midstream, downstream river basin e.g. Ichalkaranji and surrounding area faced the problem more severely. A majority (70.77%) of the diseases were observed in the months of May and June i.e. and followed by (20%) in the months of April and May. minimum epidemics (9.23%) were observed in the months of September and October. According to the some respondents (32.31%), the main cause of spread of diseases was pollution of water bodies in the area. According to many (41.54 %) drinking water and some (21.54 %) poor drainage system were the serious problems faced during epidemics. Lastly, according to most respondents (92.31%) there is definite increase in the frequency of the epidemics in the recent years. The respondents suggested that proper drainage system (23.08%) and protection from pollution (10.77%) can prevent the epidemics.

Conclusion:

The results revealed that the water quality of Panchganga river is gradually deteriorating. It was also observed that in general in Panchganga river basin more waterborne diseases were reported in and around Ichalkaranji city than at Prayag Chikhali. It was observed that there were more epidemics in the Month of February during 2010 to 2012. In May, i.e in peak summer season, water quality index was found to be minimum i.e. of Bad category in Panchganga river water. During the three year period the number of affected people due to the waterborne diseases was more in year 2012, where Panchganga river water quality index was the worst.

Panchganga River water Quality index and MPN of drinking water in the study sites was highly negatively correlated, it means as water quality goes on deteriorating the MPN count also goes on increasing showing maximum vulnerability of locals to water borne diseases.

It was observed that Panchganga river gets polluted due to negative human impact from the nearby catchment through disposal of untreated domestic sewage and industrial effluents from villages, towns and cities located on the bank or in the river catchment, resulting into increase in waterborne diseases in villages, towns and cities. The observations also revealed that the epidemics in general were experienced by locals one or two times in a year, and majority of them are waterborne diseases. As compared to the upstream and midstream, downstream basin was facing more severe problem. The majority of the diseases were observed in summer and least the late rainy season, when river pollution is low. The main cause of epidemics in the study area was due to pollution of water bodies in addition to improper sewage and effluent drainage in river. Quality of drinking water and in adequate drainage system is the main serious problems during epidemics in the district. There is increase in the frequency of these epidemics in last few years.

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