Assessment of Quality of river water in the state of Odisha-A case study of the Rivers Kuakhai, Daya and Bramhani

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Abstract: ***Among the many pitfalls associated with heightened Urbanization and Industrialization, degradation of quality of river water is a prominent one. The level of urbanization world over is on the rise as more than half (54.83%) are residing in the urban areas (The World Bank Group, 2019). Most of the world's major urban centres have come up in and around some river basin. Urban areas world over depend on the river basins to meet with the water requirements for their households, industrial activities and maintain the hydrological cycle. In India discharge of untreated sewerage is the leading cause of pollution of the rivers and other water bodies (Kala S. Sridhar, 2013). Bhubaneswar and Rourkela are two leading urban centres in the state of Odisha which are situated along the banks of rivers Kuakhai, Daya and Bramhani respectively. The steep rise of population and economic activities in the two cities have catapulted the generation of households and Industrial waste which are being discharged into the rivers resulting into sharp deterioration in the water quality. Biological Oxygen Demand (BOD) and Total Coliform (TC) are two prominent indicators whose level determines the level of contamination of water. This study attempts to study the trend of these two indicators in the rivers of Kuakhai, Daya and Bramhani.***

Keywords: Urbanization, River basins, untreated sewage, water quality, BOD, TC

I.INTRODUCTION

The impact of water pollution of rivers is wide-spread and is not restricted to isolated locations as the impact is extended to the downstream areas from the specific areas where the pollutants are dumped. The adverse health impacts of the polluted river waters have now been well known. A study done in the context of rivers in China states that, one grade deterioration in their water quality increases the chances of digestive Cancer by 9.7% (Ebenstein, 2012). In another study in the neighbouring country of Bangladesh it is seen that an additional year of exposure to high-risk water sources due to faecal contamination enhances the probability of 1-year infant mortality by 27% (Field, 2011). Ground and surface water are the principal sources of water supply for the households in India. Surface water is drawn from the scarce natural water bodies such as river, lakes, ponds etc.

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It has been observed that cities with large population depend more on surface water as opposed to ground water (Mukherjee, 2010). Surface water faces the threat of degradation due to organic pollution which is measured by the level of bio-chemical oxygen demand (BOD) & Total Coliform (TC) present in them(Gangwar.S, 2013). Domestic sewage is one of the leading pollutants of the river waters in India. Class-I cities (Greater than 1 lac population) generate 93% of India's total urban sewerage estimated at 35558.12 million litres per day (MLD). The sewage treatment plants in the Class-I cities have a capacity to treat nearly one-third (32%) of the sewage generated. Bulk of the sewerage treatment capacity i.e. 69% exist in the 35 metropolitan cities whereas the remaining 463 Class-I cities have 31% of treatment capacity (Central Pollution Control Board, 2013). There is rise in generation and dumping of solid waste into water results into lowering of Oxygen level during its decay and cause die-off plants and animals (S.Uttara, 2012).

"Water (Prevention and Control of Pollution) Act, 1974" is an important legislation enacted with an objective to preserve the country's aquatic resource, prevent them from the acts of pollution and maintain their wholesomeness. The term "Designated best use- (DBU)" was coined which categorized the water bodies into five (5) classes. Each class of water body was based upon the purpose for which it was used which was determined by presence on designated elements in a sample of water drawn from the water bodies. Each class of water body had varied levels of BOD and TC along with other elements which indicated the level of their contamination. BOD is an indicator of organic pollution on account of waste water while TC is an indicator of bacterial contamination. The following are the classes of water bodies based on their uses.

I. Class- A- Drinking water source without conventional treatment but after disinfection (BOD ≤ 2mg/l and Total coliform ≤ 50 MPN/100ml)
II. Class-B-Outdoor Bathing (BOD ≤ 3mg/l and Total coliform ≤ 500 MPN/100ml)
III. Class-C- Drinking water source with conventional treatment, followed by disinfection. (BOD ≤ 3mg/l and Total coliform ≤ 5000 MPN/100ml)
IV. Class-D- Fish culture and wild life propagation.
V. Class-E- Irrigation, industrial cooling or controlled waste disposal.

As per Central Pollution Control Board (CPCB) norms river water can be categorized as "Clean" if the BOD level

of less than 3mg/litre while water bodies with BOD level of more than 6 mg/l is regarded as " Heavy to Severe Pollution". Based on "DBU" determined by the CPCB, river water is considered fit for bathing if the BOD level < 3mg/l presence of faecal coliform count is within a range of 500MPN/100ml(desirable) and 2500 MPN/100 ml (Maximum permissible). Due to impact of pollution majority of the waters of rivers near to the cities in India are classified as C and D category.

Source of surface water for the cities of Rourkela and Bhubaneswar

The cities of Bhubaneswar and Rourkela are the leading urban centres in the state of Odisha. Kuakhai and Daya a tributary and sub-tributary respectively of the river Mahandi, flow along the city of Bhubaneswar. The river Bramhani originates at the confluence of rivers Koel and Sankha at Veda-Vyas near Rourkela. These are among the eleven rivers basins in Odisha which are rain fed. Mahanadi and Bramhani are 1st and 2nd largest rivers in the state of Odisha with catchment area of 65628 and 22516 sq.km respectively (CES,Dept of Forest and Enviornment, Govt of Odisha, 2014). Kuakhai and Bramhani are the major source of water supply to the cities of Bhubaneswar and Rourkela respectively. Over the years all these rivers have been polluted heavily due to increase in human and industrial activities. Municipal sewage is considered to be the main pollutant of water. Most of the sewage receives no treatment before discharge in all the cities of Orissa (Nayak K. M., 2014).

The river'Brahmani' flows through many districts of Odisha before emptying into the Bay of Bengal at Dhamra. The maximum catchment area the river is in the district of Sundargarh in which the city of Rourkela is located. The city has the presence of Rourkela Steel Plant, Fertilizer Plant, Captive Power Plant, Cement Factories, Heavy Refectories, Distillery Units and 300 MSME's in the areas and these units discharges their effluents and domestic waste water in the river. As per the standards of Central Pollution control Board, India, water of Bramhani has been classified as "C" category in Rourkela. (Trinath Biswal, 2018) .

The river'Mahanadi' runs a distance of 494 km in Odisha and has 5 main tributaries and 4 distributaries. There are 34 urban centres and towns in the Mahanadi river basin in Odisha. As per the estimate of Odisha State Pollution Control Board (OSPCB) the urban locations discharge 3, 45,000 m^3 of waste water into river Mahanadi every day which results into BOD load of 68.8 tonnes daily (Nayak K. M., 2014) . The River Mahanadi branches into Kathojodi at Naraj from where it bifurcates into river Kuakhai which flows along the city of Bhubaneswar. In Bhubaneswar city urban waste water is discharged through Gangua nallah without treatment to river Daya. Kuakhai and Daya rivers control the drainage of Bhubaneswar city. A number of open drains pass through the city, some of which form the Gangua nallah which meets river Daya at Benabilli (K.K Agrawal, 2018)

Table. 2 Daily Water supply from surface water sources and sewage generated in Bhubaneswar and Rourkela

City	Water Supply (MLD)	% of Water supplied through surface water	Sewage generated(MLD)	Sources of Surface water
Bhubaneswar$	265	84.15	90	Kuakhai, Daya& Mahanadi at Mundali
Rourkela #	47.90	100	38	Bramhani &Koel

Source: # City sanitation Plan-Rourkela Municipality, $City sanitation plan for Bhubaneswar

Table 2 above shows that in the cities of Bhubaneswar and Rourkela there is a significant amount of dependency on the surface water to meet the water requirements. The source of the surface water for both cities is the rivers which flow along them. In both the cities there is absence of sewage treatment plants due to which the waste water are directly discharged into the rivers of the two cities(AMRUT, 2015) and (NIUA, 2017). The resultant impact is deterioration in the quality of the river water which has been studied in the following section.

II.METHODOLOGY

The trend of intensity of pollution has been analysed by finding the trend and difference of BOD and TC levels at upstream (u/s) and downstream (d/s) monitoring stations in the cities of Rourkela and Bhubaneswar. In the city of Rourkela the u/s monitoring station at Panposh area and Average annual level of TC and BOD has been taken for the period 2000 to 2017 (Table-4). The data has been put to paired sample t-test to find the average difference in mean of BOD and TC of the water at the upstream and downstream monitoring stations. Since BOD and TC have shown high erratic fluctuation over years, 3 years moving average of the values of BOD and TC have been computed to find the general trend. The trend of BOD and TC of (u/s) and (d/s)river have been passing through the Rourkela and Bhubaneswar has been studied using linear regression model with time as the dependent variable.

III.ANALYSIS AND FINDINGS

Table. 3 Comparison of u/s and d/s in water quality of water in Kuakhai, Daya and Bramhani, for the period (2000-17)

City	Water quality	N	Mean	SD	p value
Rourkela	Panposh U/S BOD	18	1.38	0.57	0.000
	Rourkela D/S BOD	18	3.16	0.48	
	Panposh U/S TC	18	4733.44	4369.09	0.001
	Rourkela D/S TC	18	20273.11	19510.61	
Bhubaneswar	Kuakhai U/S BOD	18	1.77	0.63	0.000
	Daya U/S BOD	18	3.63	0.67	
	Kuakhai U/S TC	18	9811.94	10918.93	0.001
	Daya U/S TC	18	34526.72	34810.01	

Source: Computed from secondary data from table-4

The average difference between the u/s and d/s BOD and u/s and d/s TC has been studied by paired sample t-test. The Mean U/S BOD was 1.38 ± 0.57 mg/ litre and Mean D/S BOD was 3.16 ± 0.48 mg/litre in river Bramhaniin Rourkela. The difference was significant (p=0.000). The Mean U/S TC was 4733.44± 4369.09 mpn /100ml and Mean D/S TC was 20273.11 ± 19510.61 mpn/100ml in river Bramhani in Rourkela. The difference was significant (p=0.001).

The Mean U/S BOD of Kuakhai was 1.77 ± 0.63µ/m^3 and Mean D/S BOD of river Daya was 3.63 ± 0.67 mg/litrein Bhubaneswar. The difference was significant (p=0.000). The Mean U/S TC of Kuakhai was 9811.94 ± 10918.93 mpn /100 ml and Mean D/S TC of Daya was 34526.72 ± 34810.01 mpn/100ml in river in Bhubaneswar. The difference was significant (p=0.001).

On an average the BOD and TC level of downstream water was significantly higher than the upstream water in the rivers of both the Rourkela and Bhubaneswar which indicated the level of pollutants being discharged into the rivers is quiet high. The average TC level of Kuakhai u/s in Bhubaneswar exceeds the limit of 5000mpn/100ml. The TC level at d/s of river Daya in Bhubaneswar is nearly 1.7 times than that of Bramhani in Rourkela.

Table. 4 Regression of BOD and TC in Bramhani, Kuakhai and Daya with time (2000-2017)

Model		Unstandardized Coefficients		t	p	R2	ANOVA p value
		B	SE				
MA3 BOD Panposh US	(Constant)	1.818	0.156	11.661	0.000	0.699	0.003
	Year	-0.059	0.016	-3.661	0.003		
MA3 TC Panposh US	(Constant)	-393.542	996.334	-0.395	0.699	0.696	0.000
	Year	583.164	103.038	5.66	0.000		
MA3 BOD Rourkela DS	(Constant)	2.653	0.126	21.12	0.000	0.775	0.000
	Year	0.06	0.013	4.592	0.000		
MA3 TC Rourkela DS	(Constant)	-4197.925	4382.919	-0.958	0.354	0.732	0.000
	Year	2800.285	453.271	6.178	0.000		
MA3 BOD Kuakhai US	(Constant)	1.948	0.241	8.084	0.000	0.069	0.324
	Year	-0.025	0.025	-1.021	0.324		
MA3 TC Kuakhai US	(Constant)	-5120.383	3282.468	-1.56	0.141	0.799	0.000
	Year	1689.033	339.465	4.976	0.000		
MA3 BOD Daya DS	(Constant)	3.298	0.217	15.234	0.000	0.065	0.342
	Year	0.022	0.022	0.983	0.342		
MA3 TC Daya DS	(Constant)	-14043.242	7451.752	-1.885	0.080	0.777	0.000
	Year	5377.016	770.642	6.977	0.000		

Source: Computed from secondary source data

The regression of BOD and TC in Rourkela and Bhubaneswar with time has been studied to capture the significant decreasing and increasing trend with time both for upstream and downstream water quality in the cities of Rourkela and Bhubaneswar. The u/s BOD level in Rourkela has shown significant decrease while d/s BOD has shown significant increase with regression co-efficient -0.059 and 0.06 respectively (p<0.01).

The u/s and d/s BOD level in Bhubaneswar has neither shown increasing nor decreasing trend (p>0.05).

The u/s and d/s TC level in Rourkela has shown significant increase with regression co-efficient 583.16 and 2800.28 respectively (p=0.000). The increasing trend is much faster in the downstream water. The u/s and d/s TC level in Bhubaneswar has shown significant increasing trend with regression co-efficient 1689.03 and 5377.02 respectively (p=0.000). However the increasing trend is much faster in the downstream water.

The intensity of waste-water pollution This indicates that the rivers of both cities are subject to release of pollutants from the cities which is resulting into high TC and BOD content in the d/s rivers.

IV.CONCLUSION

The TC of d/s waters both at Bramhani and Daya far exceeds the limit of 5000mpn/100ml and BOD 3.0 mg/l which indicates that water of the river are not healthy and not fit even for human bathing. The level of wastewater and bacterial contamination has been found to be higher in the city Bhubaneswar than Rourkela which raises the threat of water-borne diseases. The industrial wastes along with household discharges add to the high pollution level that may result into nervous disorders, kidney diseases, skin ulceration, cancer, destruction of tissues and red blood cells etc. Immediate measures should be taken to set up sewage and waste treatment plants and ramp up the capacities of the existing ones in order to prevent the rivers from getting further polluted and result into some major human and ecological catastrophe in the area.

Table. 5 Levels of Biological oxygen demand and Total coli form in the river water in Bhubaneswar and Rourkela (2000-2017)

Years	Panposh u/s		Rourkela d/s		Kuakhai u/s		Daya d/s	
	BOD	TC	BOD	TC	BOD	TC	BOD	TC
2000	3.00	994	3.20	2017	3.40	1123	5.00	4040
2001	2.20	2036	2.90	5082	2.40	6669	3.90	10283
2002	2.20	3032	3.40	9023	2.60	4857	3.90	10294
2003	1.40	2657	2.30	8675	1.50	2425	3.00	7133
2004	1.20	2116	3.00	6067	1.20	1633	3.10	7700
2005	1.00	3770	2.70	9682	1.30	3876	2.80	15330
2006	1.20	1605	2.80	4900	1.10	1727	3.20	17250
2007	1.15	1273	2.28	15365	1.40	1475	3.00	12150
2008	1.23	3529	3.05	11323	1.50	1425	3.30	12825
2009	1.08	1553	3.58	8883	1.80	2492	4.00	25475
2010	1.40	2098	3.18	9652	2.10	2768	3.60	11258
2011	1.20	3492	3.90	12583	2.10	6392	3.40	26942
2012	1.70	6075	3.20	33025	2.40	7225	3.10	40783
2013	1.20	10280	3.30	68840	2.00	22460	3.30	49300
2014	0.80	7709	3.80	44091	1.50	31218	3.60	85727
2015	0.90	7400	3.50	18650	1.30	26642	3.40	74908
2016	0.90	18625	3.90	49500	1.20	26833	4.70	93833
2017	1.00	6958	2.90	47558	1.10	25375	5.00	116250

Source: (State Pollution control Board Odisha, 2016)

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