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An Analytical Study of Assessment of Class of Water Quality on River Brahmani, Odisha

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ABSTRACT: The present investigation is aimed at assessing the current water quality standard along the stretch of Brahmani River in terms of physico-chemical parameters. In the selected study area the River Brahmani is receiving a considerable amount of industrial wastes and witnessing a considerable amount of human and agricultural activities**.** Twelve samples were collected along the entire stretches of the river basin during the period from January-2000 to December-2015 on the first working day of every month. In the selected research area, the Brahmani River is receiving the domestic, industrial, and municipal waste waters/effluents all along its course. Various physico-chemical parameters like pH, Nitrate (NO_3), Total Dissolved Solids (TDS), Boron, Alkalinity, Calcium, Magnesium, Turbidity, Chloride Cl^-) , Sulphate (SO_4^{2-}), Fluoride(F^-) and Iron(Fe) etc. were analysed. The present study indicates that the water quality of Brahmani River is well within tolerance limit taking the physico-chemical parameters into considerations.

Keywords: Brahmani River, Physico-chemical parameters, pH, TDS, Alkalinity, Tolerance limit.

I. INTRODUCTION

Water, a prime natural resource, is a basic need for sustenance of human civilization. Sustainable management of water resources is an essential requirement for the growth of the state's economy and well being of the population. As per National water policy, 2002, water resources development and management will have to be planned for a hydrological unit such as drainage basin as a whole or for a sub-basin for sustainable use incorporating quantity and quality aspects as well as environmental considerations.

The water environment quality is a very important and is a subject of major concern for economic development of any country. The water resource problems related to degradation have increasingly been serious because of rapid industrialization and urban sprawl. Anthropogenic influences such as urbanization, industrial and agricultural activities, increasing consumption of water recourses along with natural process i.e. change in precipitation inputs, erosion, effectively deteriorate surface water quality and impair their uses for drinking, industrial, agriculture, recreating and other purposes.

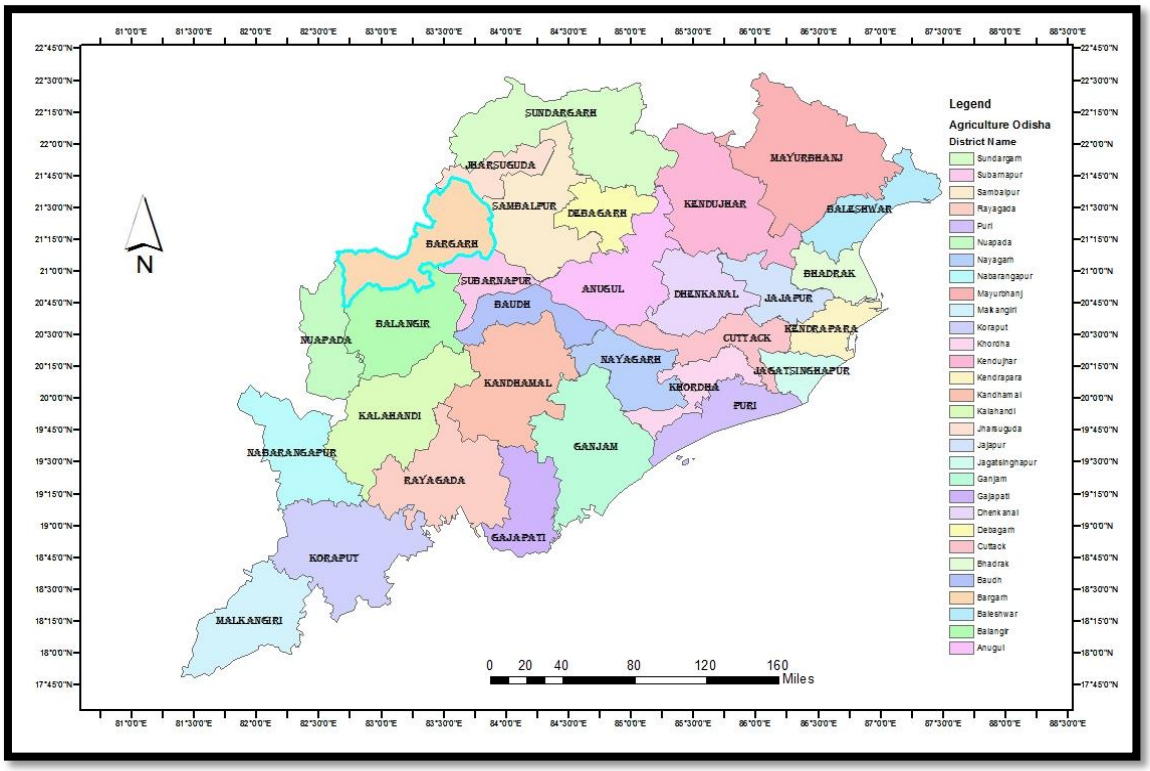
II. STUDY AREA AND DATA COLLECTION

STUDY SITE:

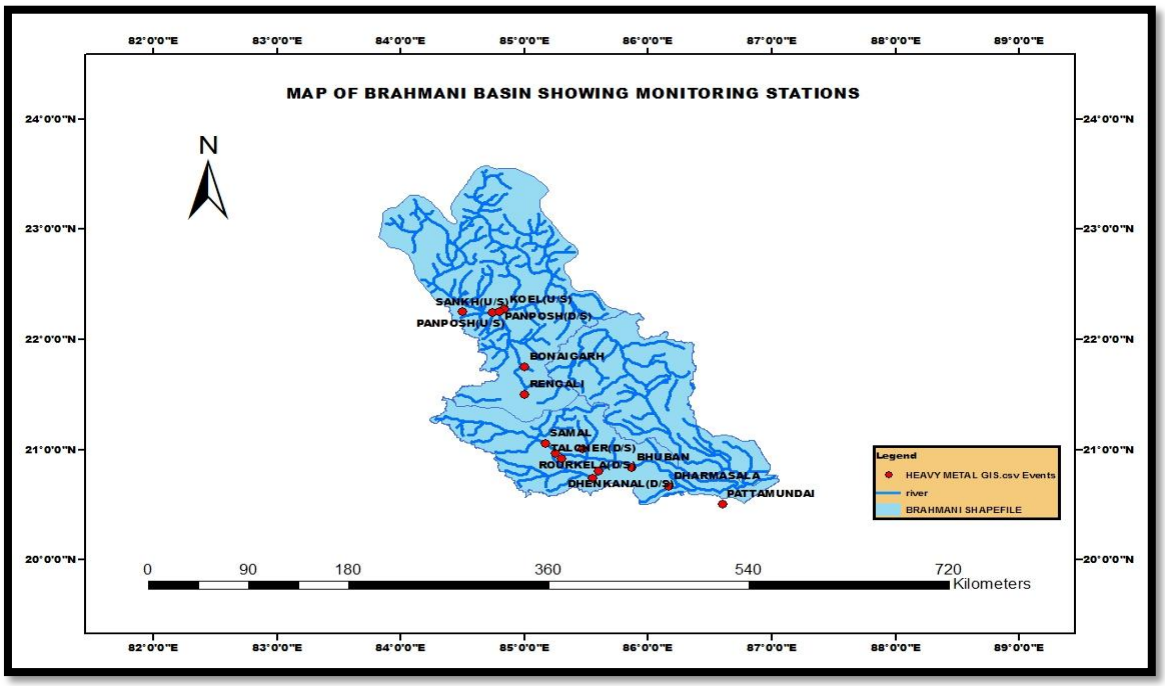
Brahmani, the second major river in Odisha, is formed by the combined waters of South Koel and Sankh rivers at Vedvyasa near Rourkela in the Sundergarh district. The left bank tributary South Koel originates near Nagri village in the Ranchi district of Jharkhand state. After its confluence with river Karo in Singhbhum district, it is known as koel. From Manoharpur, it flows in the south-west direction for a distance of about 54 km uptoVedvyasa where the right bank tributary Sankh joins with it. River Sankh originates an elevation of 1000 m near village Lupungpat in Ranchi district of Jharkhand state.

River Brahmani travels southward through valleys incised in the Gadjat Hills to form the famous Gangpur Basin. In this stretch the river is joined by several fast flowing tributaries. The deltaic region of Brahmani starts from Jenapur at river distance equals to 315 km, where the Kalamitra Island divides the river into two branches. The left branch is called Brahmani main and the right branch is called Kharasuan, which agains join the Brahmani River at RD 429 km.

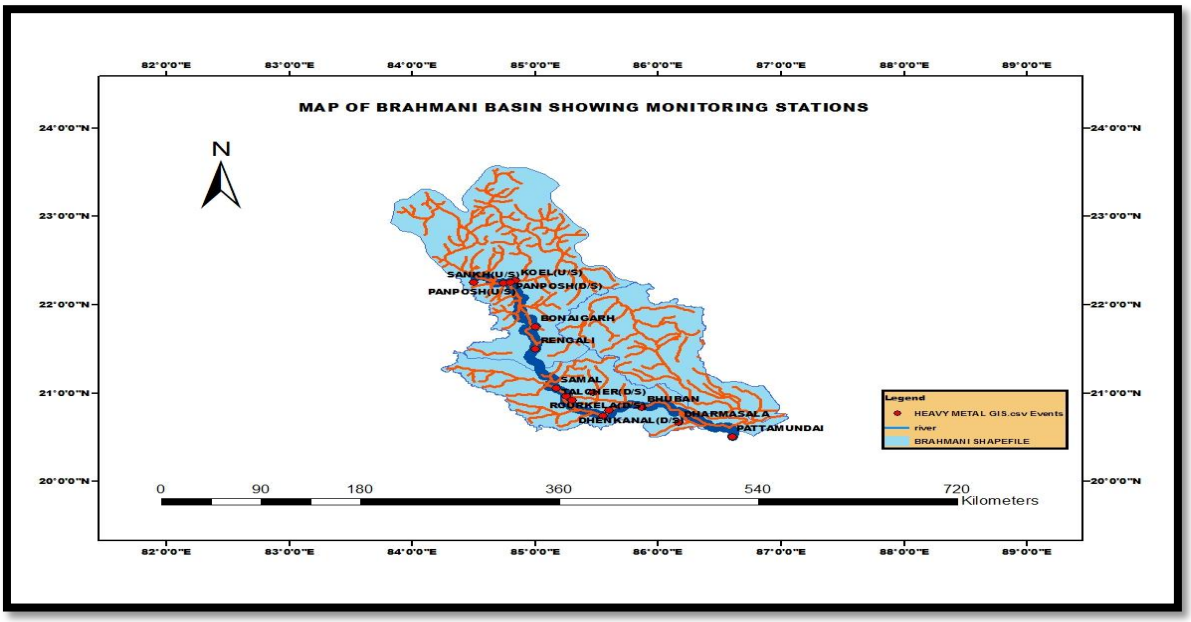
The below (figure 1, 2, 3,4) showing monitoring stations of Brahmani basin by the application of GIS Software.



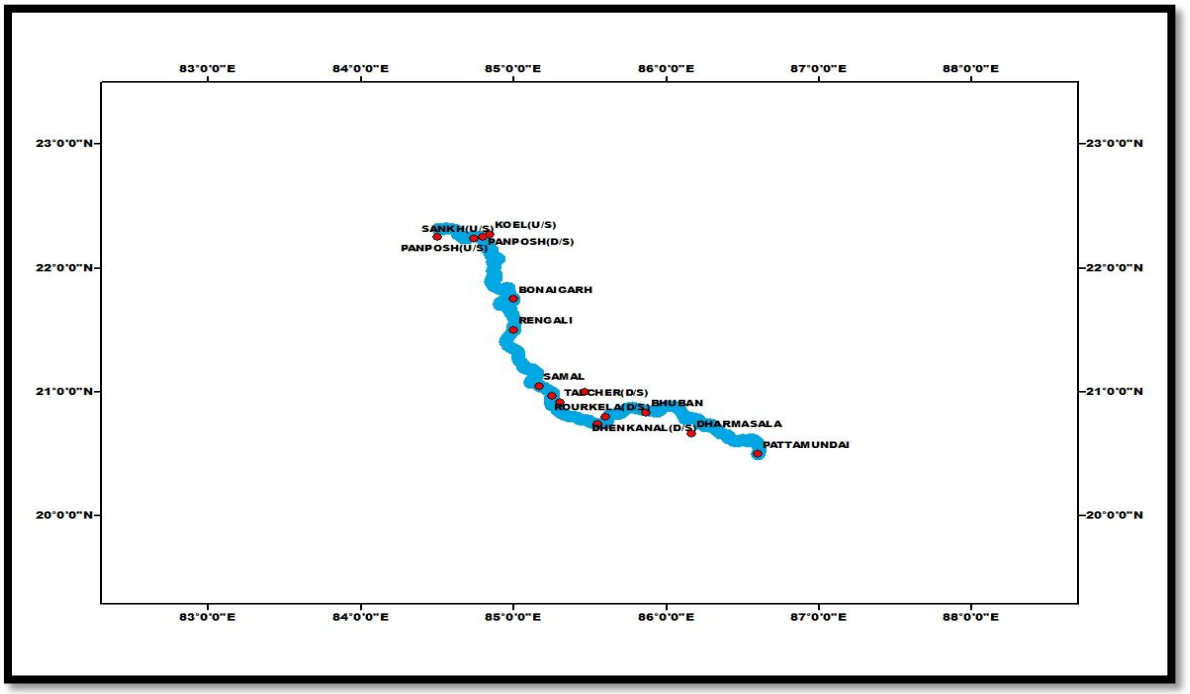
(Figure1. Districts of Odisha showing Angul, Talcher&Dhenkanal of Brahmani Basin)



(Figure2.Brahmani basin showing fifteen monitoring stations)



(Figure3. Flow path of Brahmani basin showing monitoring stations)



(Figure4.Brahmani basin showing flow path accompanied with monitoring stations)

Fifteen different stations as mentioned below are selected across the stretch of the Brahmani River. The selection of the sites and classes was done depending upon the industrial and mining activities along the river bank (Table 1,2)

Table1.Showing the monitoring stations and the justification on the site selected

SL NO	MONITORING STATION	JUSTIFICATION ON THE SITE SELECTED
1	SANKHA(U/S)	D/S OF MANDIRA DAM
2	KOEL(U/S)	BEFORE CONFLUENCE WITH RIVER SANKHA AND AFTER WASTE WATER DISCHARGE OF KOEL NAGAR
3	PANPOSH(U/S)	WATER QUALITY BEFORE INDUSTRIAL ACTIVITY AFTER CONFLUENCE OF SANKH AND KOEL

4	**PANPOSH(D/S)**	**IMPACT OF INDUSTRIAL ACTIVITIES LIKE RSP AND DOMESTIC WASTE WATER DISCHARGE FROM ROURKELA CITY.**
5	**ROURKELA(D/S)**	**TO ASSES WATER QUALITY IMPROVEMENT AT FURTHER DOWN STREAM OF ROURKELA CITY AND IDENTIFICATION OF POLLUTED STRETCH.**
6	**BONAIGARH**	**TO ASSESS THE IMPROVEMENT OF WATER QUALITY.**
7	**RENGALI**	**A MULTIPURPOSE DAM**
8	**SAMAL**	**SAMAL BARRAGE, WATER INTAKE POINT FOR TSTPP, KANIHA**
9	**TALCHER(U/S)**	**WATER INTAKE POINT OF INDUSTRIES AND MINES**
10	**TALCHER(D/S)**	**IMPACT OF INDUSTRIAL AND MUNCIPAL DISCHARGE. DOWNSTREAM OF THE CONFLUENCE OF NANDIRA JHOR WITH BRAHMANI**
11	**DHENKANAL(U/S)**	**UPSTREAM OF DHENKHANAL TOWN**
12	**DHENKANAL(D/S)**	**DOWNSTREAM OF DHENKHANAL TOWN**
13	**BHUBAN**	**A MAJOR HUMAN SETTLEMENT WITH WATER INTAKE POINT**
14	**DHARMASALA**	**THICKLY POPULATED AREA WITH INTENSIVE AGRICULTURE PRACTICE D/S OF INDUSTRIAL ACTIVITIES AT KALINGA NAGAR**
15	**PATTAMUNDAI**	**THICKLY POPULATED AREA, TIDAL EFFECT**

Table2.Standard prescribed tolerance limits for inland surface water

STANDARD PRESCRIBED TOLERANCE LIMITS FOR INLAND SURFACE WATER	
CLASSES	**USE BASED CLASSIFICATION**
CLASS-A	**DRINKING WATER SOURCE WITHOUT CONVENTIONAL TREATMENT BUT AFTER DISINFECTION**
CLASS-B	**OUTDOOR BATHING**
CLASS-C	**DRINKING WATER SOURCE WITH CONVENTIONAL TREATMENT FOLLOWED BY DISINFECTION**
CLASS-D	**FISH CULTUIRE AND WILD LIFE PROPAGATION**
CLASS-E	**IRRIGATION, INDUSTRIAL COOLING OR CONTROLLED WASTE DISPOSAL**

III. MATERIALS AND METHODS

SAMPLING AND PARAMETERS: Water samples were collected from 15 stations along the course of theBrahmani river system, starting from the Sankh U/s Reservoir to Pattamundai. The sampling strategy was designed in such a way to cover a wide range of determinants at keysites that accurately represent the water environment quality of the river systems and account for tributary inputs that can have important impacts upon downstream water quality. Various water quality parameters from the monitoring stations were analyzed yearly from 2000 to 2015. The mean value of the data sets (Table 3) was taken into consideration for evaluating the pollution load in the water system. The measured parameters include pH, Nitrate(NO_3), Total Dissolved Solids (TDS), Boron, Alkalinity, Calcium, Magnesium, Turbidity, Chloride (Cl^-), Sulphate (SO_4^{2-}), Fluoride(F^-) and Iron(Fe).

Table 3.MINIMUM, MAXIMUM, MEAN AND STANDARD DEVIATION OF WATER QUALITY PARAMETERSAT DIFFERENT MONITORING STATIONS FROM 2000 TO 2015

PARAMETERS	STATIONS	MIN	MAX	MEAN	STANDARD DEVIATION
PH	**15**	**7.478**	**7.821**	**7.681933**	**0.093202136**
TURBIDITY	**15**	**61.625**	**164.3**	**93.48833**	**24.89554116**
TDS	**15**	**71.66667**	**234.1667**	**111.0889**	**46.27446293**
CALCIUM	**15**	**12.29**	**30.06**	**16.78933**	**5.76978146**
MAGNESIUM	**15**	**4.1325**	**11.50167**	**6.102334**	**2.419139123**
IRON	**15**	**1.323833**	**5.828917**	**2.858724**	**0.995811285**
CHLORINE	**15**	**9.1**	**28.01**	**13.82713**	**5.609048963**
FLUORINE	**15**	**0.21075**	**1.593833**	**0.494911**	**0.428257389**

NITRATE	**15**	**1.705833**	**30.365**	**4.184667**	**7.263498**
SULPHATE	**15**	**7.138**	**37.55**	**14.71427**	**10.31852366**
ALKALINITY	**15**	**36.885**	**75.06333**	**48.48828**	**12.9094684**
BOR0N	**15**	**0.033333**	**0.178333**	**0.076278**	**0.038847244**

IV. RESULTS AND DISCUSSION

WATER QUALITY TREND OF BRAHMANI BASIN

Sankh River

Water quality of this river is monitored at only one location before its confluence with Koel River at vedvyas. As there is neither any urban centre nor any organized domestic waste water discharge to the river, the water quality remains at the class C level.

Koel River

Water quality of this river is monitored at only one location before its confluence with Sankh River at Vedvyas. As the monitoring location is upstream to the domestic waste water discharge points to Koel River, the water quality at the monitoring location remains at the Class C level.

Brahmani River

Brahmani River is formed by the combined waters of koel and sankh Rivers at vedvyasa. Water quality data at panposh U/s (vedavyasa) generally remains at class C level. From the data, it is seen that there is deterioration of water quality at Panposh D/s and Talcher D/s. This is an expected observation since a number of large and medium industries and mines are operating at Rourkela and Angul-Talcher industrial complex.

The spatial variation of water quality is in a predictable way. By the time the river reaches Bonaigarh there is a significant improvement in water quality, which remain more or less the same up to Talcher U/s through Rengali and Samal, since there is no major urban settlements or waste water outfalls in this stretch.

After confluence of Nandira River with Brahmani River, the water quality at Talcher D/s deteriorates both with respect to BOD and TC. Though BOD value increases in comparison to U/s stations of Talcher still it remains within the prescribed limit of 3.0 mg/l, where both TC and FC counts significantly exceeds the prescribed limit. The water quality gets improved uptoDhenkanal U/s. Impact of Dhenkanal town on the water quality of Brahmani River is not that much significant irrespective of increase in TC and FC counts.

After Bhuban, there is some restoration in the water quality which continues uptoPottamundai through Dharmasala (about 108 km). The magnitude of improvement in the water quality in this stretch is however not the same as that in the Bonaigarh-Rengali-Samal stretch, since there is increase in the population density and intensity in agricultural activities as the river enters into the deltaic region.

During the eighties and early nineties, the water quality of the river at Rourkela and Angul-Talcher caused much concern. Presently, however, there is no indication of any severe industrial pollution in these two stretches. This could be because of some effective control measures taken by the industries and mines, subsequently.

A significant step in this direction is recycling/reusing of waste water by some of the major polluting units and reduction in the quantity of effluent generation by some large industries. Improvement in the water quality over the years is reflected in the water quality trend at Talcher D/s and the rivulet Nandira. This small tributary of Brahmani originates at Golabandha and after travelling a distance of about 39 km, joins Brahmani at kamalnaga. Most of the major industries and mines in the Angul-Talcher area are located in the catchment of Nandira. Till late nineties, it is used to receive effluent (directly or indirectly) heavily laden with suspended solids and other pollutants, from many major industries. With improved pollution control measures and recycling of waste water, the quantum of effluent discharged to Nandira has now been reduced considerably, leading to a significant improvement in its water quality and hence at Talcher D/s.

Kharasrota River

It originates from Brahmani River at Jenapur and after travelling a distance of 150 km rejoins with BrahmaniRiver before the confluence of Brahmani and Baitarani rivers at Dhamra. There are neither any major towns or urban settlements or industries located on the bank of kharasrota River. Therefore, the water quality remains at class-C level uptoBinjharpur. However, the human activities on river water has increased significantly at Aul which is evident from the increased TC and FC count Values.

V. WASTE WATER GENERATION

INDUSTRIAL SOURCES

A number of large industries have been established in Rourkela, Angul-Talcher, Dhenkhanal area of the basin. Close to delta head, at Duburi, another major complex of steel plants is located. List of large

industries operating in the basin is shown in the Table. The locations of these industries are indicated in the figure. Besides the existing industries there are proposals for 13 thermal power plants of total capacity generates 14770 MW and integrated steel units of capacity 6 Million Ton/ annum, in Brahmani basin. Most of the existing industries have appropriate effluent treatment plants (ETP) and the treated waste water, unless completely recycled or reused, is discharged into some tributary, which ultimate drains into the Brahmani River. A notable development in the pollution control measures during the last decade is complete recycling of the overflow from the ash ponds of the coal based thermal power plants. Earlier the ash pond overflow laden with high suspended solids was a major factor, particularly in Angul-Talcher area, for pollution of Nandira and hence the Brahmani River (Table4).

Table4.Major industries in Brahmani Basin in Odisha

MAJOR INDUSTRIES IN BRAHMANI BASIN IN ODISHA		
SL NO.	**NAME OF THE INDUSTRY**	**PRODUCTS**
1	**SHIVA CEMENT LTD.,KUTRA, SUNDERGARH**	**CEMENT**
2	**CHARIOT CEMENT LIMITED, KAUNGA**	**CEMENT**
3	**ROURKELA STEEL PLANT (RSP), ROURKELA**	**POWER**
4	**ROURKELA STEEL PLANT (CPP-II), ROURKELA**	**POWER**
5	**NTPC-SAIL COOPERATIVE LTD. (CPP-II), ROURKELA**	**SLURRY EXPLOSIVE**
6	**GULF OIL CORPORATION LTD.,(IDL INDUSTRIES LTD.), ROURKELA**	**CEMENT**
7	**OCL LTD. (CEMENT), RAJGANGPUR**	**REFRACTORY BRICKS**
8	**OCL INDIA LIMITED (REFRACTORY UNIT), RAJGANGPUR**	**POWER AND STEEL**
9	**KALINGA IRON WORKS,BADBIL**	**POWER**
10	**TALCHER SUPER THERMAL POWER STATION (NTPC), KANIHA**	**ALUMINIUM**
11	**NATIONAL ALUMINIUM COMPANY (SMELTER UNIT), ANGUL**	**POWER**
12	**NATIONAL ALUMINIUM COMPANY (CPP UNIT), ANGUL**	**POWER**
13	**TALCHER THERMAL POWER STATION(NTPC),TALCHER**	**POLY FIBRE YARN**
14	**ORISSA POLY. FIBRE LTD. (OPFL)-(PFY UNIT), DHENKHANAL**	**POLYESTER STALE FIBRE**
15	**ORISSA POLY. FIBRE LTD. (OPFL)-(PSF UNIT), DHENKHANAL**	**SUGAR**
16	**SAKTI SUGARS LTD. (SUGAR UNIT), DHENKANAL**	**RECTIFIED SPIRIT**
17	**SAKTI SUGARS LTD. (DISTILLERY UNIT), DHENKANAL**	**POWER AND FERROALLOYS**
18	**NAVABHARAT VENTURES LTD., DHENKANAL**	**POWER**
19	**BHUSAN ENERGY LTD,. DHENKANAL**	**SPONGE IRON**
20	**BHUSAN STEEL LTD,. DHENKANAL**	**ASBESTOS CEMENT**
21	**UAL ORISSA, UAL INDUSTRIES LTD.**	**POWER AND STEEL**
22	**JINDAL STAINLESS LIMITED, KALINGA NAGAR**	**POWER AND STEEL**
23	**MIDEAST INTEGRATED STEELS (MESCO) LTD., KALINGA NAGAR**	**POWER AND STEEL**
24	**VISA STEEL LTD., KALINGA NAGAR**	**POWER AND STEEL**
25	**NEELACHAL ISPAT LTD., KALINGA NAGAR**	**POWER AND STEEL**
26	**MAITHAN ISPAT LTD., KALINGA NAGAR**	**POWER AND STEEL**

27	**ROHIT FERROTECH LTD., KALINGA NAGAR**	**POWER AND STEEL**
28	**DINABANDHU STEEL AND POWER LTD., KALINGA NAGAR**	**POWER AND STEEL**
29	**K.J.ISPAT., KALINGA NAGAR**	**POWER AND STEEL**

MINING SOURCES

The Brahmani basin is known for its rich mineral deposits of coal, chromite and iron. There are 12 number of coal mines of Mahanadi coal fields limited existing in basin. Wastewater from the coal mines generally consists of mine drainage water, workshop effluent and domestic waste water. The major problem constituents in the workshop effluents are oil, grease and particulates.

The coal mines in the area have settling tanks for mine drainage water and oil/grease traps for the workshop effluents. Domestic waste water is either treated in sewage treatment plants (STP) or discharged to soak pits via. Septic tanks. The combined treated waste water is discharged into Brahmani directly or through small tributaries. Part of the mine drainage water is used for dust suppression.

There are 22 numbers of chromites mines operating in the basin. The chromite mines have their individual effluents treatment plants (ETP) for treatment of hexavalent chromium in mine drainage water. The treated effluent is then discharged into Damsalanallah, whivh ultimately joins Brahmani river through another small tributary (Ramiala).

A number of iron and manganese ore mines are operating in Brahmani basin portion of keonjhar and Sundergarh districts. Out of these, major iron ores are Bolani, Bhadrasahi, Thakurani ,ML Sarada and SL Sarada. Mine discharge water from these areas flow towards Karo River which is a sub-tributary of river Brahmani and flows mostly in Jharkhand state (Table5, 6).

Table5.Coal Mines Operating in Brahmani Basin in Odisha

COAL MINES OPERATING IN BRAHMANI BASIN IN ODISHA		
SL NO.	**NAME OF COAL MINES**	**TYPE**
	ANGUL	
1	**JAGANNATH COLLIERY**	**OPENCAST**
2	**BHARATPUR COLLIERY**	**OPENCAST**
3	**KALINGA (BALRAM) COLLIERY**	**OPENCAST**
4	**ANANT COLLIERY**	**OPENCAST**
5	**LINGARAJ COLLIERY**	**OPENCAST**
6	**CHHENDIPADA COLLIERY**	**OPENCAST**
7	**HINGULA COLLIERY**	**OPENCAST**
8	**BHUBANESWARI COLLIERY**	**OPENCAST**
9	**DEULBERA COLLIERY**	**UNDERGROUND**
10	**HANDIDHUA COLLIERY**	**UNDERGROUND**
11	**TALCHER COLLIERY**	**UNDERGROUND**
12	**NANDIRA COLLIERY**	**UNDERGROUND**

Table6.Chromite Mines in Brahmani Basin in Odisha

CHROMITE MINES IN BRAHMANI BASIN IN ODISHA		
SL NO.	**NAME OF CHROMITE MINES**	**TYPE**
	JAJPUR DISTRICT	
1	**SUKINDA (TISCO)**	**OPENCAST**
2	**SARUABIL (MISRILA)**	**OPENCAST**
3	**KAMARDA (B.C.MOHANTY)**	**OPENCAST**
4	**TAILANGI (IDCOL)**	**OPENCAST**
5	**KALIAPANI (BALASORE ALLOYS)**	**OPENCAST**
6	**SOUTH KALIAPANI (OMC)**	**OPENCAST**
7	**OSTPAL (FACOR)**	**OPENCAST**
8	**CHUNGUDIPAL (IMFA)**	**OPENCAST**
9	**KATHPAL (OMC)**	**OPENCAST**
10	**SUKARANGI(OMC)**	**OPENCAST**

11	**KALIAPANI (JSL)**	**OPENCAST**
12	**SUKINDA (IMFA)**	**OPENCAST**
13	**SUKINDA (TISCO)**	**OPENCAST**
14	**KALARANGIATTA (FACOR)**	**OPENCAST**
15	**KAMARDA BALIPADIA(OMC)**	**OPENCAST**
16	**KALIAPANI (IMFA)**	**OPENCAST**
17	**KALARANGI (OMC)**	**OPENCAST**
18	**BALIAPADA (MAHAGIRI) OMC**	**OPENCAST**
19	**KATHPAL (FACOR)**	**UNDERGROUND**
DHENKANAL		
20	**KATHAPAL (FACOR)**	**OPENCAST**
21	**KATHPAL (OMC)**	**OPENCAST**
22	**BIRASAL (OMC)**	**OPENCAST**

DOMESTIC SOURCES

There are 11 urban local bodies in the basin. Domestic waste water generation from urban settlements and industrial townships in the basin is about 90,000 m³/day. None of these places except the industrial townships of Rourkela, Talcher Thermal, NTPC, and NALCO have any sewage treatment plant (STP). Consequently most of the untreated domestic waste water flowing in the drains these urban settlements finds its way to river Brahmani, contributing a total BOD load of about 17.9 tons/day (assuming BOD concentration of sanitary wastewater is 200 mg/l) directly or indirectly. Since the villages do not have any organized water supply or drainage, the waste water is totally absorbed (Table 7).

Table7. Urban Local Bodies in Brahmani Basin In Odisha

URBAN LOCAL BODIES IN BRAHMANI BASIN IN ODISHA			
DISTRICT	**SL NO.**	**ULB**	**POPULATION CENSUS**
KEONJHAR	**1**	**BARBIL MUNCIPALITY**	**52,586**
	2	**BIRAMITRAPUR MUNCIPALITY**	**29,434**
	3	**RAJGANGPUR MUNCIPALITY**	**43,912**
SUNDERGARH	**4**	**ROURKELA (CIVIL TOWN) MUNCIPALITY**	**2,24,601**
DEOGARH	**5**	**DEOGARH MUNCIPALITY**	**20,085**
	6	**ANGUL MUNCIPALITY**	**38,022**
ANGUL	**7**	**TALCHER MUNCIPALITY**	**34,984**
	8	**BHUBAN NAC**	**20,134**
DHENKANAL	**9**	**DHENKANAL MUNCIPALITY**	**57,651**
	10	**KAMAKSHYANAGAR NAC**	**15,002**
KENDRAPADA	**11**	**PATTAMUNDAI NAC**	**32,724**

AGRICULTURAL SOURCES

The basin has 11 completed, 3 ongoing and 18 numbers of proposed major and medium irrigation projects. Besides these, there are 169 completed and 202 numbers of ongoing minor irrigation projects in the basin. Hence the quantity of water used for irrigation is quite large. Such large abstraction of water for irrigation is bound to affect the qualitative regimes of the surface as well as ground water sources in the area,since run-offs from agricultural fields (estimated to be about 12% of the water used for irrigation), containing fertilizers and pesticides, are considered to be a major non-point pollution source. The wastewater flow from agricultural sector in Brahmani basin in Odisha part is of the order of 405.6 million m³ per year.

Assuming the loss of N,P,K and pesticides as 10%,5% (due to lower solubility), 10% and 5% respectively, their estimated concentration in return water due to application of fertilizers and pesticides in Brahmani basin. However, one comforting aspect is, since application of a major portion of fertilizers is during the kharif, their inflow into the river is mostly during the monsoon, when sufficient water is available in the river for dilution and reducing their impacts (Table 8).

Table8. Estimated Concentration of N, P,K and Pesticides In Agricultural Return Water

ESTIMATED CONCENTRATION OF N,P,K AND PESTICIDES IN AGRICULTURAL RETURN WATER DUE TO APPLICATION OF FERTILIZERS AND PESTICIDES IN BRAHMANI BASIN IN ODISHA		
COMPONENT	**CONSUMPTION (T/YEAR) DURING 2010-2011**	**ESTIMATED CONCENTRATION IN RETURN WATER (405.6 ,MILLION M^3/YEAR) MG/L**
N	**25160.62**	**6.2**
P	**14183.56**	**1.75**
K	**7038**	**1.74**
PESTICIDES	**138**	**0.02**

VI. CONCLUSION

The present study reveals that the water quality of Brahmani River is quite safe as compared to the physico-chemical parameters point of view at present. However, due to increased industrial and human activities along its bank a constant monitoring of the water quality of the river is a must to maintain the river water quality.

APPLICATIONS

The present study is useful in ascertaining the water quality of Brahmani River along its entire stretch for its potability for industrial, agricultural and human use.

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