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RESEARCH ARTICLE

ANTHROPOCENE EFFECTS ON THE RIVER DAYA AND THE LAGOON CHILIKA BY THE EFFLUENTS OF BHUBANESWAR CITY INDIA: A PHYSICO-CHEMICAL STUDY.

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Abstract

Bhubaneswar city poses problems of liquid waste disposal and allow it to a natural drain (Gangua drain) to the river Daya which is the hydrographic life line of South Mahanadi delta and major fresh water source to the largest lagoon of Asia, the Chilika. Use of river water from the Daya, face the challenge of meeting compliance economically by national regulatory standards to maintain riparian rights of the people and the ecology downstream. Present study is conducted to determine the physicochemical standards and the heavy metals polluting of the river upstream, the main drain Gangua Nallah and the water quality downstream in 2017. The digital equipments are used to find the physical, biological parametric values and for heavy metals by the XRF spectrometer. The water quality parameters determined are pH, DO, BOD, COD, TDS, Ca, P, K, Ni, Ca. The heavy metals and the REE'S were also determined during the flow. The result shows the water quality during non-monsoon is deteriorating matching with the Anthropocene impacts. Weekly water samples were taken for the non-monsoon and monsoon to study the chemical toxicity and their impact on day to day behavior to decide the human activity and manage the brain chemistry as guided by neurotransmitters. The results are compared with the previous studies made CPCB and other researchers.

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Introduction:-

The municipal areas of Bhubaneswar is 135 Km² (Latitude- 20°12' N to 20°25' N and Longitude 85°44' E to 85°55' E.) and the peripheral developmental area is 233 Km². The area used under residential, commercial, industrial, administrative, institutional and other utilities are 49.61 Km², 3.64 Km², 6.23 Km², 4.08 Km² and 10.93 Km² respectively. Still vast areas in the suburbs are under construction as residential complexes and satellite cities.

Daily water supply of 182 MLD (except personal drawls) to Bhubaneswar and corresponding liquid waste is 145.6 MLD (80%). The total BOD load as organic matter as suspended is 100.64 t/day and dissolved solids is 127 t/day. In undulated valley topography and without any integrated liquid waste treatment the entire liquid waste and storm water is disposed to the Kuakhai or Daya River flowing in the outskirts of the city. For sludge disposal most of the

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families are using septic tank in small or large. Open yard defecation is still in practice even within Bhubaneswar Municipal Corporation (BMC) area.



Figure 2:- The main sampling station near Kanti kotha beda village after confluence of Gangua Nallah. (Source: Google)

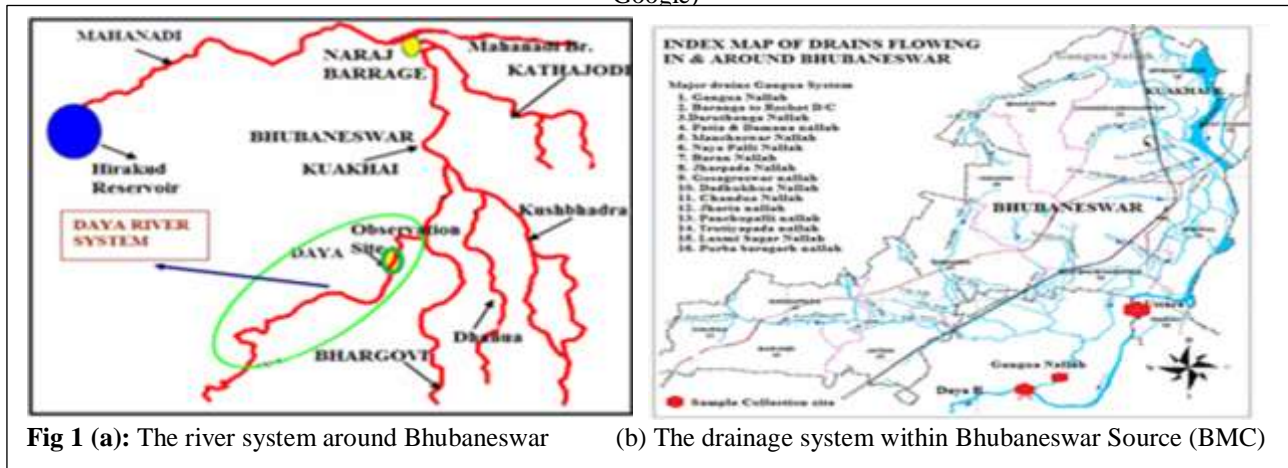


Fig 1 (a): The river system around Bhubaneswar (b) The drainage system within Bhubaneswar Source (BMC)

The mega delta of Mahanadi has an area of 9500 Km² and average water potential of 46.969 BCum (data 1986-2011). The bifurcated branch Kathajodi at Naraj throws its first southern limb Kuakhai at 5Km downstream near Village Trisulia which circumscribes the capital city Bhubaneswar (BBSR) of Odisha and its satellite extensions. The river Kuakhai further avulse to make Kushabhadra branch in the north of BBSR and further bifurcate to the branches Daya and the Bhargovi. The consumption of water for 9.05 lakhs habitats is mostly met from the rivers Kuakhai and Daya as source. In addition there are ten numbers of major anastomosed drains in India emphasizes supply of suitable, sufficient and safe drinking water to its citizens. Swachh Bharat Avijan (SBA-2014), Clean India Mission (CIM-2014), Odisha State water Policy (2007) and National Water policy (2002) demands to clean the polluted rivers at both tributary and distributaries level prioritizing public health by supplying safe drinking water, water for irrigation/hydropower, mandates water supply near schools sanitation and for city maintenance. The clean river projects demanded univocally throughout the globe and various projects were taken up under Minister of Water Resources, River Development and Ganga Rejuvenation, 2011, GOI. Projects were taken up under Jawaharlal Nehru National Urban Renewal Mission Plan (JNNURM), Housing and Urban Development Department, Govt of Odisha (HUDD) to clean liquid effluents of towns in Odisha and supplying safe water to individuals.

The population of Bhubaneswar has increased from 14512 in 1951 to 905339 with respect to burgeoning population of Odisha 44.86 billion in 2016. The withdrawal of portable water have increased exponentially in last four to five decades. There are two industrial clusters consisting of 88 industries out of which 34 are vulnerable for water

pollution (BMC data). Simultaneously the liquid waste in the form of domestic, biomedical and industrial have faced acute problem of disposal. The township is growing fast and all the liquid wastes are drained directly to the Daya.

Gangua drainage system:-

Gangua drain flows between ayacuts of Daya West branch canal and Lingipur distributary from NW to SE outskirts of Bhubaneswar. The Nallah flows for a length 37km, drains from catchment area of 756 Km² with an approximate runoff of 652 Cumec with major 10 numbers of secondary drains of length 37.18Km flowing in and around Bhubaneswar city. The drains are directly draining to Daya River at Kantikotha Pada and polluting villages Manitri, Oupada and below the river Daya. During the summer the river is dry and carries the liquid waste of Bhubaneswar town. In the year 1915, the water of river Daya became dark and was unsuitable for domestic use of the stake holder downstream for 15 days. The average flow at before/after bifurcation of the Daya and Bhargovi from Kuakhai, and after confluence of the Gangua drain are 105.02 Cumec, 55.00 Cumec and 88.90 Cumec respectively. The total solids as waste enter the Daya River via Gangua drain from is 103.23 t/day. The sources from domestic, industrial and other sources of liquid waste supply were 47.6 MLD, 29.3 MLD and 30.35 MLD respectively (SPCB, Govt. of Odisha Report 2002). The major drains of the gangua drainage system are given in Table-1:

Table 1:- The major drains flowing in Bhubaneswar City and draining to Daya, Dash A. K. 2010^[2]

#	Drain name	Starting from	Outfall Point	River	Length Km	Catchment Ha.	Discharge MLD
1	Gangua nallah	Chanadka Forest	Daya R.	Daya	37.18	10343	107.25
2	Patia & Damana	Patia forest	Daya west canal	Kuakhai	4.32	1693	17
3	Mancheswar	Sainik School	Ganguanallah	Daya	1.13	144	1.55
4	OAP area	Vani Vihar	Gangua nallah	Daya	2.42	331	3.55
5	Barana	Vani Vihar	Gangua nallah	Daya	5.63	1367	16.4
6	Jharpada	Old Rly station	Ganguanallah	Daya	3.13	366	4.45
7	Baragarh drain	Baragarh area	Ganguanallah	Daya	2.16	289	3.45
8	Gosagareswar	Old Bhubaneswar	Ganguanallah	Daya	4.34	946	5.45
9	Airport area	Baramunda	Ganguanallah	Daya	4.33	1299	14.3
10	Ghatikia	Aiginia	Ganguanallah	Daya	4.24	1255	28.8
11	Nicco park drain	CRP Area	Ganguanallah	Daya	5.48	1028	12.3

Present study:-

The Orissa State Pollution Control Board (OSPCB) has admitted that high levels of coliform bacteria are present in the water of the rivers below Daya Bridge (NH 203) and Kuakhai has been polluted to be unfit for human use. Odisha Human rights commission has alleged about direct release of untreated liquid waste/sewage from capital city to the rivers Kuakhai and Daya. OSPCB reported regarding DO, BOD, COD and E coli were beyond permissible limits in the Daya water



Confluence of a D/C to Gangua Drain



Planktons/ Cyano Bacteria covered Chilika



After all D/C joining main Gangua drain



Confluence point Daya & Gangua in Monsoon

Fig 3:- Photographs from a drain to Chilika Lagoon via Gangua drain and the Daya River carrying Pollutants

The Orissa State Pollution Control Board (OSPCB) has admitted that high levels of coliform bacteria are present in the water of the rivers below Daya bridge (NH 203) and Kuakhai has been polluted to be unfit for human use. Odisha Human rights commission has alleged about direct release of untreated liquid waste/sewage from capital city to the rivers Kuakhai and Daya. OSPCB reported regarding DO, BOD, COD and E coli were beyond permissible limits in the Daya water **Dash A. K. 2010**^[2]. At village Manitri, the Daya River has coliform bacteria level observed as 61,317 in 100 ml water instead of the permissible limit of 500. At Kanti, after confluence point of Gangua nallah and Daya, the coliform count was 74,908 per 100 ml which is toxic for life of both plants and animals. But the Kuakhai river at Hanspal and Mancheswar (7 and 10Km upstream) had coliform bacteria counts was 5,552 and 26,642/ 100 ml respectively (Odisha Post, June 24th, (2016) <http://www.orissapost.com/daya-kuakhai-water-unfit-for-human-use/>). The cause for this rate of increase of pollutants can be the effect of Anthropocene epoch. <http://bmc.gov.in/Population.aspx>, The rate of population growth (Fig -4) is decreasing. However the trend in population growth is exponential and matching the Anthropocene concept.

The river Daya receives the effluents attains an abnormal E-Coliform count / physic- chemical standards and concentration (conc.) of heavy metals and finally fall in the lagoon Chilika. Hence it became pertinent to monitor continuously the water quality of Daya from time to time. Present study is an attempt to find the physicochemical characteristics of Daya water in pre monsoon and monsoon period. Also the concentration of heavy metals and radioactive elements present in the effluent need to be attended by Bhubaneswar Municipal Corporation (BMC) which is a smart city in India. If pertinent action shall not be taken from today, the Daya river shall become like the Yamuna river at Delhi, the Gomati river in Luck now. The downstream river and lagoon users shall lose their riparian rights and the lagoon shall be deserted from guest avifauna, shall be a dead zone for the aqua fauna and imbalance the ecology of the South Mahanadi delta.

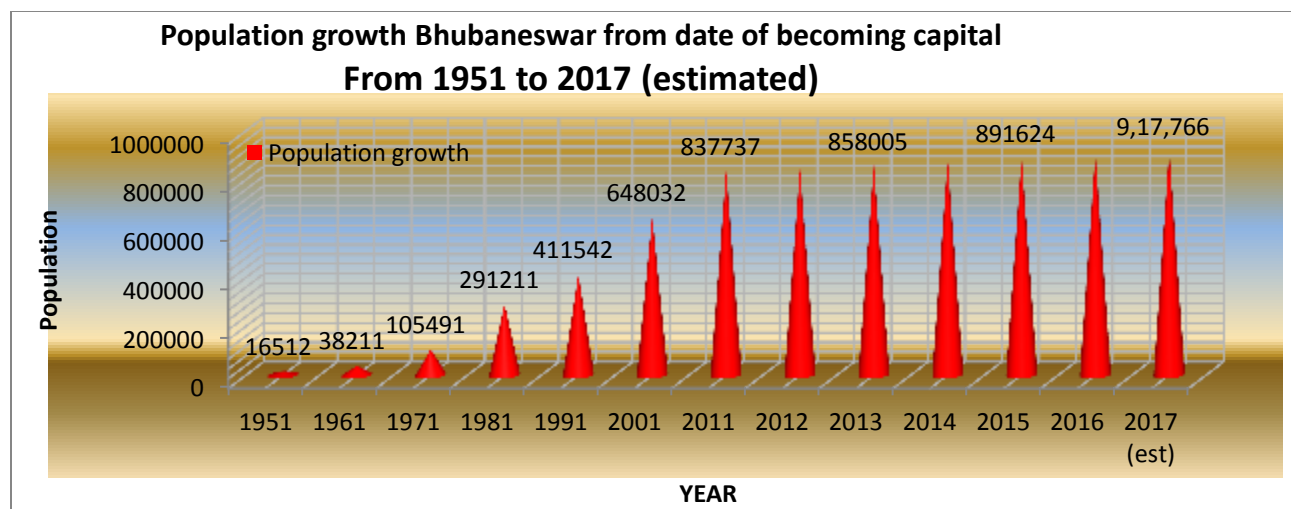


Fig 4:- Population growth Bhubaneswar from date of becoming capital From 1951 to 2017 (projected)

Review of Literature:-

Increased levels of traces of toxic metals are components of municipal/industrial, and effluents which is detrimental to health of human and biotic environment (Singh S. et al., (2011)^[3]. Mahood et al., 2013^[4]. Maiti et al 2015^[5] studied the heavy metals in drinking water samples from various sources and claimed there is need for constant monitoring as the levels of pollution as the presence of trace metals are alarming. Das et al (2013)^[6]. studied the waste water at Lake near NICCO Park and Mahapatra et al, 2014^[7] reported that the water quality of the rivers Kuakhai and Daya are deteriorating after analyzing and calculating the different physico-chemical parameters of water samples. Hegazi H. A. (2013)^[8] observed that rice husk and Fly ash can reduce the efficiency of heavy metals like Cu, Ni and iron in water. Karnib et al., (2014)^[9] have removed heavy metal Ni²⁺ from polluted water by using activated carbon, silica and silica activated carbon composite. Barakat M. A. 2011^[10], have experimentally proved that effective digestion inorganic industrial effluent can be done up to concentration of >1000 mg/L of metals by lime precipitation. Biofilters/ or bioabsorb/or bioaccumulates are popular at present to reduce conc. of heavy metals in addition to conventional treatment procedures Rodrigues, (2011)^[11]. The Dept. of Environmental Protection and Energy, New Jersey's, USA uses KDF 55 or 85, redox alloy medium for removing mercury which is cost effective http://www.kdff.com /success_metal.htm. Halawaa et al 2015^[12], reported Pb, Cd, Cu and Zn can be effectively reduced from polluted river water by using dithiocarbamate ligands as they are good binders and precipitate heavy metal ions as complexes. Prokaryotic organisms like Cyanobacteria plentifully found in lacustrine environments like rivers and lagoons which are harmful to both human being, aquatic plants and can be filtered by fibers from endocarp of dried coconut shell, macadamia nut shell, mesocarp of green coconut, residue of pine wood and bagasse of sugarcane Albuquerque E. C. de Jr. et. al.,(2008)^[13] and Landsberg J. H., (2002)^[14]. Zeolites, clay, peat moss can reduce the pollution. Self-cleansing of the pollutants can be done by methods of adsorption by using industrial wastes and agricultural wastes Tripathy et. al.(2015)^[15]. Mishra et al 2015^[16] have studied the drinking water quality of South Mahanadi delta and reported for first four to five km from coast the ground water is saline. OPCB has described the water of Daya is of class B (CWC classification) and beyond Manitri is class -C. Mishra S. P 2016 has reported that the coastal Odisha except some villages are fit for irrigation. Behera et. al., 2017^[17] studied the Physico chemical behavior of coastal Puri district and showed that it is fit for irrigation except some few patches. Lohani et al 2011^[18], Mishra and Nayak^[19], 2014 Mishra et al., 2015^[20], has reported that Daya river is a part of South Mahanadi delta and its water is becoming polluted day by day by Gangua drain.

Methods and methodology:-

Scarcity of innocuous drinking water and acceptable nutrition are the key factors behind mortality of infants and adults in India. Diarrhoea, ARI (Acute respiratory syndrome), Pneumonia and various acute diseases like typhoid, malaria, and hepatitis has increased the CDR (Crude death rate) and IMR (Infant mortality rate) in Odisha. The CDR rates in 2001 were nervous, respiratory and digestive systems were 20 % of fatalities. The IMR rates due to intestinal, infectious, and parasitic diseases were (21.68%) respectively in 2000 due to polluted water. For safe water, the necessity of maintaining norms of the water supply is important.

Heavy metals have high atomic weight and density than that of water. The high grade of toxicity Zn^{2+} , Ni^{2+} , Cd^{2+} , Cr^{2+} , Pb^{2+} , Cu^{2+} and As^{2+} are prioritized as toxic metals affecting human health significantly. The affected species are Hg in fish, lead in bone broth, Cadmium in e-cigarettes and Arsenic in rice. The chemical toxicity and their impact on day to day behavior decide the human activity and manage the brain chemistry as guided by neurotransmitters. Our behavioral aptitudes like pleasure, anger, relaxations, food habits, and weekly cleaning activities are the reflections. Manifestations in human actions are depression, anxiety, addiction and psychosis etc. are the results of heavy metals and Proteins present in water. Monitoring of chemical parameters, heavy metals and rare earth metals were done on each day in a week from Sunday to Saturday and samples for two weeks (one in monsoon and other in non-monsoon) were collected and studied.

For collection of the representative samples of water is drawn as per the IS 1622 -1981 and IS 3025-1994 (Part 1). The Indian standard methodology procedures are adopted to find the values of water quality parameters and is compared with the water quality standards prescribed by IS specification like IS: 3025 (Part 1): 1986, IS: 3025 (Part 38): 1989, IS: 7022 (Part 2): 1979 and IS: 2296-1992. But for rivers Central pollution control board (CPCB), India have classified the rivers according to use as Class –A to Class E. For drinking water standards IS 10500: 2012 is followed. The classification for limnic/ riverine ecosystem, designated best use of river water or primary water quality benchmark and their physic chemical parameters as reported By CPCB and Global sustainable surface water UNECE-1994 (www.oecd.org/env/eap) are in Table -2

Table 2:- The designated best use of river water, class, their criteria (Source: CPCB 1991 and UNECE 1994)

Class	Primary use	Minimum standards CPCBE	Minimum Standards UNECE
A (I)	Drinking Water Source without conventional treatment bafter disinfection	1.Total Coliforms: MPN/100ml : 50 or less 2. pH between 6.5 to 8.5 3. Dissolved Oxygen 6mg/lit or more 4. Biochemical Oxygen Demand (BOD) 5 days 20 °C, 2mg/l or less	1.TC: MPN/100ml: 50 or less 2. pH between 6.5 to 9.0 3. Dissolved Oxygen 7mg/lit or more 4. Chemical Oxygen Demand (COD) 20 0C, <3mg/l
B (II)	Outdoor bathing (Organised)	1.Total Coliforms : MPN/100 ml shall be 500 or less 2. pH between 6.5 to 8.5 3. Dissolved Oxygen 5mg/l or more 4. Biochemical Oxygen Demand 5 days 20 °C, 3mg/l or less	1.Total Coliforms : MPN/100 ml shall be 500 or less 2. pH between 6.05 to 6.3 3. Dissolved Oxygen 6-7mg/l 4. Chemical Oxygen Demand (COD) 20 0C, 3-10 mg/l
C (III)	Drinking water source after conventional treatment and disinfection	1. Total Coliforms: MPN/100ml shall be 5000 or less 2. pH between 6 and 9 3. Dissolved Oxygen 4mg/lit or more 4. Biochemical Oxygen Demand 5 days 20 °C, 3mg/lit or less	1. Total Coliforms: MPN/100ml shall be 5000 or less 2. pH between 6.0 to 6.3 3. Dissolved Oxygen 4-6mg/lit 4. Chemical Oxygen Demand (COD) 20 °C, 10-20mg/lit
D IV)	Propagation of Wild life and Fisheries	1. pH between 6.5 and 8.5 2. Dissolved Oxygen 4mg/lit or more 3. Free Ammonia (as N) 4. Biochemical Oxygen Demand 5 days 20 °C, 2mg/l or less	1. pH between 5.3 to 6.0 2. Dissolved Oxygen 3-4mg/lit 3. Free NH ₃ (as N):1500 to 2500 4. Chemical Oxygen Demand (COD) 20 °C, 20-30mg/l
E (V)	Irrigation, Industrial Cooling, Controlled Waste disposal	1. pH between 6.0 and 8.5 2. Electrical Conductivity at 25 °C micro mhos/cm, maximum 2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg/l	1. pH < 5.3 2. DO < 3, 3. Alkalinity <10 4. COD >30 5. Free NH ₃ (as N):> 2500 6. Boron Max. 2mg/l

Physicochemical Parameters:-

Water quality parameters are Physical, chemical, toxic metals, organic bacteriological, biological and Radioactive metals (REE). The physical parameters are colour, odour, taste, turbidity, pH, conductivity and TDS whereas chemical parameters are hardness, ions of Ca^{+2} , Mg^{+2} , K^{+1} , Cl^{-1} , F^{-1} , SO_4^{-2} , NO_3^{-1} , PO_4^{-3} and alkalinity. The toxic and heavy metals are Cu, Cr, Cd, Pb, Hg, Fe, Mn, As and the organic nutrient or demands are biological oxygen demand (BOD), Chemical Oxygen demand (COD), pesticides, phenols, nitrates, oils and greases. The

bacteriological parameters are total coliform (TC) and Faecal coliform (FC) and biological parameters are phytoplanktons and Zoo planktons etc. The rare earth elements are the α -emitters and γ – emitters. Sample collection on different days and their preservation of the water collected and effect of the highly concentrated physico-chemically, heavy metals and rare earth element found in the sample with limits for usable standards for the riparian stakeholders downstream are listed in table 3.

Table 3(a):- Physical Parameters, Limits, health concerns and the apparatus (samples drawn as per IS 1622 -1981 and IS 3025-1994 (Part 1)

Parameters	Referred (IS code)	Usable Std.Limits	Health concerns of users on excesses.	Apparatus used in Lab of CUTM, and source
Temperature	IS 10500 : 2012 And UNECE-1994	Natural temp. variation Ind:10-30 ⁰ C	Increases plant growth/ algal blooms, harmful to the local ecosystem and aquaculture. Fish growth optimum at 15 ⁰ C	http://www.fondriest.com/environmental-measurements/parameters/water-quality/water-temperature
Colour	IS 10500 : 2012	5-15 hazen	Red-Fe –Lungs Infection. Brown—Mn-Parkinson, lung embolism/ bronchitis. Yellow- soil- No effect. Blue/ Green- Cu-vomiting, diarrhea, gastrointestinal distress. Foamy/cloudy – Turbid-no effect	(http://extoxnet.orst.edu/faqs/safedrink/colors.htm)
Odour	IS 10500 : 2012	Agreeable	Metallic taste –Fe or Mn Rotten Egg- H ₂ S Musty/ unnatural smell: Pesticides Turpentine taste or odor: methyl tert-butyl ether (MTBE)- cancer	http://extoxnet.orst.edu/faqs/safedrink/colors.htm
Taste	IS 10500 : 2012	Agreeable		
pH	IS 10500 : 2012	6.5-8.5	Health benefits like anti-aging , colon-cleansing immune system support weight loss, deoxidant prop., cancer resistance. Causes alkalosis resulting nausea, vomiting, hand tremors, confusions	Electronic pH meter: (www.healthline.com/health/food-nutrition/alkaline-water-benefits-risks#risk-factors)
Turbidity	IS 10500 : 2012	01 to 05	Medium for microbial growth and can cause nausea, cramps, diarrhea and associated headaches.	https://www.epa.gov/sites/production/files/documents/PN_Turbidity_BoilAdvisory.pdf
TSS mg/l	IS 10500 : 2012	500-2000	laxative effects, heart disease, Increases hardness	www.who.int/water_sanitation_health/dwq/chemicals/tds .

The water quality parameters (WQP) of the river Daya was observed during non-monsoon when the flow is lean and not even knee dip. For the month Dec to Feb from 2000, the discharge of the river Daya is closed by a temporary cross bundh (dam) to supplement irrigation to the 30000Ha in and around the lake Chilika. The water of the river Daya carries the effluent of the Bhubaneswar city only in pre-monsoon period. The norms fixed by federal agencies for biological parameters are in tab -3 and the monsoon flow and effluent combined dilute to concentration of effluent which is also observed and reported in Table 4

Table 3:-Limits, health concerns and the apparatus used to find Biological Parameters

Parameters	Referred (IS code)	Usable Std. Limits	Health concerns of users on excesses	Apparatus used in Lab of CUTM, and source
DO (mg/lit)	IS 3025 (38) 2003 CPHEEO-2012, Environmental pollutants Part –	4 (UNECE - 1994 (min) tolerable up to 5	Too high or too low can harm aquatic life and affect water quality. – Fish Kills – Gas Bubble Disease– Dead Zones	http://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen
BOD (mg/lit)	A, Schedule IV Env. Prot. rule 1986, National river conservation Directorate guide	30-350 (min -30 CPCB norms)	Reduce Do level. Accelerate bacterial growth, consume the oxygen levels in the river. Loss of bio-diversity, Anoxia,	Eldo_PPT-Indian Standards_WWT.pdf. https://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/devwtrplan_b.pdf

COD (mg/lit)	lines for faecal coliforms IS 10500 : 2012	250	Reduce Do level. Threats to human health, Growth of toxic algal blooms from organic wastes and sea food contamination,	Eldo_PPT-Indian Standards_WWT.pdf. http://www.fao.org/docrep/009/t1623e/T1623E03.htm
TDS (mg/lit)	IS 10500 : 1991	500-2000	Gastro intestinal irritations; corrosion or incrustation Hardness, scaly deposits, sediment, cloudy colored water, staining, salty or bitter taste, corrosion of pipes and fittings	http://www.indiawaterportal.org/sites/indiawaterportal.org/files/indian_standard_for_drinking_water

N.B.: Recommended value of parameter on discharge to surface water: used as source for drinking water

During monsoon the distributary Daya receives 4-5% of the flood of the Mahanadi system, the water quality of monsoon months (JJASO) from non-monsoon period (NDJFMAM) months. The water quality samples of the Daya River have been monitored for the months July and September 2017 for one week each at vulnerable points in Gangua Nallah (Benabili), before/after confluence point (Anantapur and Kantikothabeda). The monsoon flow and effluent are diluted to lower the concentration of effluent and addition of new elements which was observed. The adulterate of the river Daya during non-monsoon and monsoon are reported in Fig -2 and Table 4.

Table 4:- The WQP (Bio-chemical) of the Polluted River Daya at Manitri Village during Non-monsoon

DAY	Temperature (In °c)		PH (hydrogen conc.)		Turbidity (In mg/l)		DO ppm/lit		BOD (mg/l) (1- 5days)		COD mg/l		TDS gm/lit.	
	Non mon soon	Mon soon	Non mon soon	Mon soon	Non mon soon	Mon soon	Non mon soon	Mon soon	Non mon soon	Mon soon	Non mon soon	Mon soon	Non mon soon	Mon soon
Mon	34	30	8.46	7.75	1.3	4.0	16.4	6.0	6.4	2.5	280	680	0.007	0.040
Tues	31	26	8.53	6.68	1.4	3.4	16.0	6.5	6.5	2.8	120	800	0.026	0.008
Wed	33	27	8.48	6.10	1.0	4.8	15.4	6.2	6.2	4.2	160	480	0.038	0.050
Thu	30	28	8.34	7.23	1.6	5.1	12.4	6.0	4.1	3.5	240	1080	0.035	0.024
Fri	33	30	7.94	7.22	1.7	3.7	9.6	7.4	3.6	4.4	280	280	0.005	0.015
Sat	30	31	8.20	7.10	2.0	2.8	8.2	6.2	3.5	3.1	360	560	0.025	0.012
Sun	35	34	8.50	7.91	1.4	4.6	20.0	5.4	2.3	2.3	440	600	0.040	0.049
Av.	32.29	29.4	6.92	7.14	1.49	4.1	14.0	6.24	4.66	3.3	268.6	640.0	0.03	0.03

From the above data it is found that temperature is high in non-monsoon period, the pH value is within prescribed limit 6.5-8.5 but during non-monsoon the water of the river Daya is more alkaline than monsoon Fig 7-(a). The turbidity is within the prescribed range except on a Thursday during monsoon. The dissolved oxygen is not within the prescribed limit so the effluent need natural/artificial aeration before entry to the river water.

The BOD value is well below the MOEF standard of 30 and recommended by CPCB for use. But the BOD value is higher during summer than rainy season. The COD value well within the prescribed standards in non-monsoon period but not during monsoon. It depicts the flood water of Mahanadi system increases the COD value during monsoon i.e. the sediment transported by the river. Interestingly it is observed the DO level is high on Sunday as it is an off day for industries, less regular activities in the city and even in biomedical sector. It is observed that the BOD is decreasing whereas the COD is increasing gradually from Monday to Sunday. During monsoon the physico-chemical parameters when studied it is found that pH value is less than that of non-monsoon period. The turbidity widely varies between 2.8 to 5.1. The dissolved oxygen level is found least on Sunday (5.8 ppm/lit) and highest on Friday (7.4ppm/l). BOD values are less than standard and COD values are much higher than the prescribed limit, it may be due to the sediments carried from other reaches (Fig -5 and Fig -6).

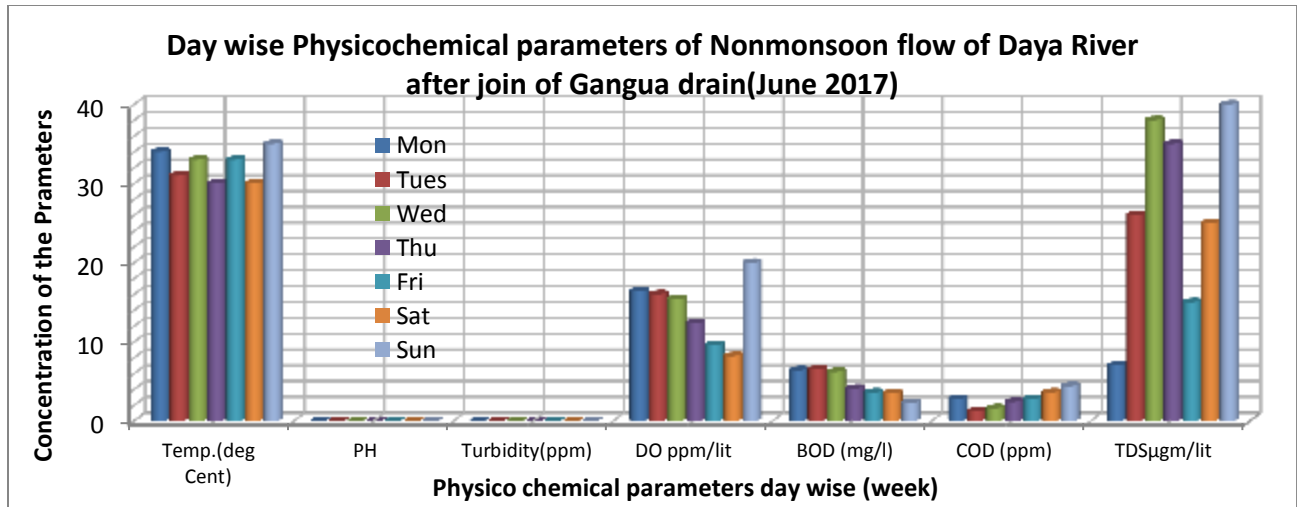


Fig 5:- Weekly Physico-chemical parameters of summer flow of Daya River after joining Gangua drain

Heavy metals and Rare earth metals:-

Based upon modern technology, different methods like X-ray fluorescence spectrometry (XRF), Polarography (AAS), Atomic absorption spectrographic method (AAS), Anodic stripping voltammetry (ASV), Neutron activation analysis (NAA) are used to determine the heavy metals sent in water. In addition Gas chromatography Analysis is also used for ascertaining and quantizing the trace and different metals (heavy or trace) present in Surface/ground water (GW).

Versatility, unique properties of XRF spectrometer have urged to access the quantity of heavy metals and rare earth elements present in the surface water samples from different vulnerable places of the river Daya. XRF spectrometer was used to find the quantities present in water sample Two standards were considered Indian Standards(IS) are meant for the Homosapiens and the United Nations Economic Commission (UNECE or ECE) standard is for ecological sustainability set standards for surface water (http://www.who.int/water_sanitation_health/resources/quality/wpcchap2) Fig 7-(b).

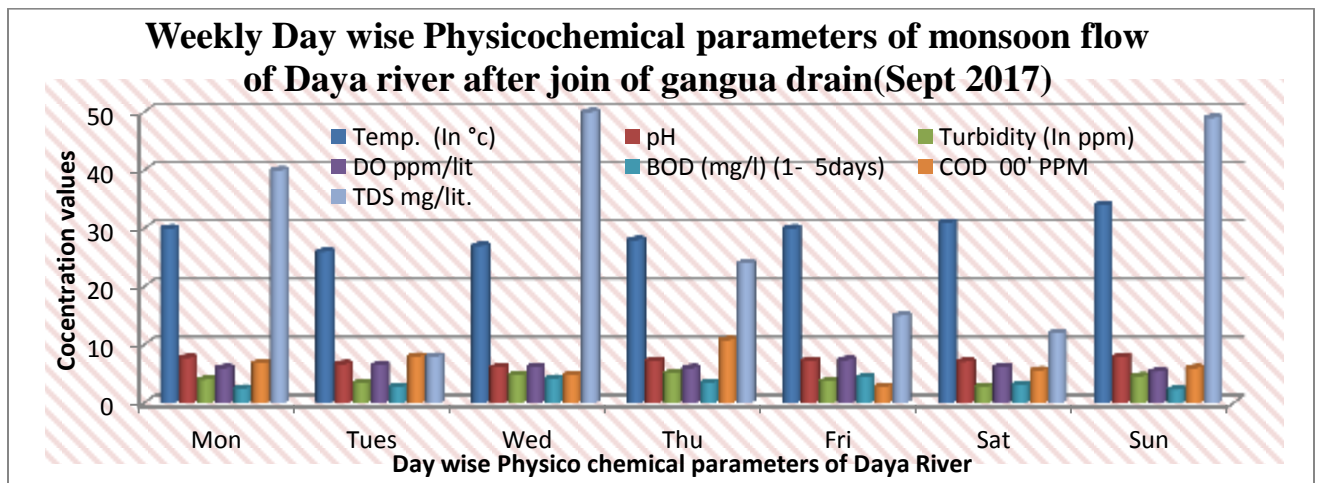


Fig 6:- Weekly Day wise physico-chemical parameters of monsoon flow of Daya R. after join of Gangua drain

XRF Spectrometer (Model: Epsilon 1 PANalytical B.V. The Netherlands) was used for elemental analysis for wide varieties of metals present in a sample of liquis, solid or composites. The standards for metals are taken from IS 10500/2012 and the standards for water quality of heavy metals are taken from Sahoo et al., 2006, [http://magazines.odisha.gov.in/Orissa Review /jan2006 /engpdf/Water_Pollution.pdf](http://magazines.odisha.gov.in/Orissa%20Review/jan2006/engpdf/Water_Pollution.pdf)

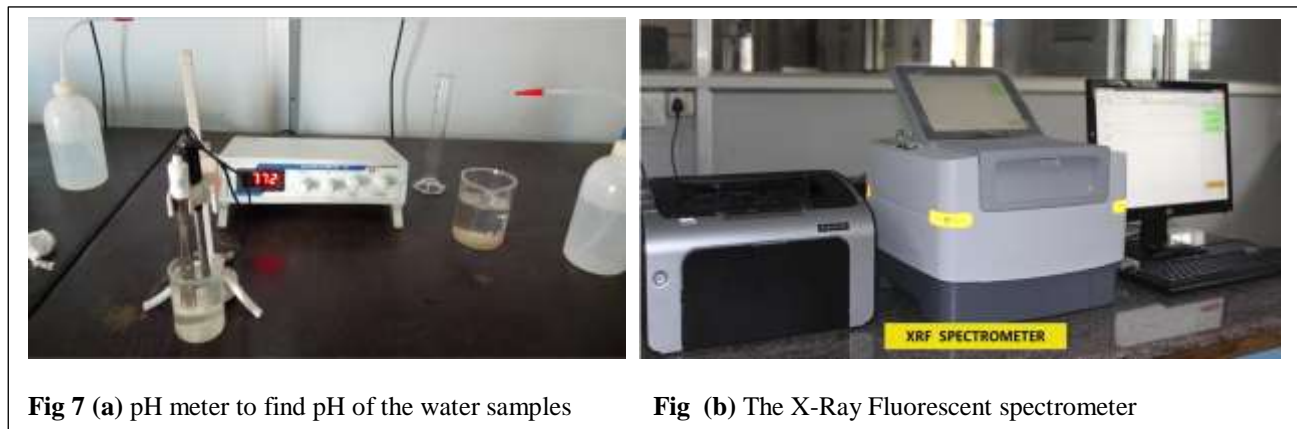


Fig 7 (a) pH meter to find pH of the water samples

Fig (b) The X-Ray Fluorescent spectrometer

Different digital instruments were also used for finding the parametric values Like pH, DO, BOD, COD, TDS, in the laboratory of Centurion University of technology and management Fig 7(a).

Table 5:- Limits, health concerns and the different standards for nonmetallic parameters

Para meters	Referred (IS code)	Standard .Limits		Health concerns of users on excesses.	Apparatus used in Lab of CUTM, and source
		WHO/U SEPA	IS		
Silica (Si)	IS 10500 /2012	20–50 mg/day	0.001 mg/l	Natural silica Nontoxic. But Eye irritant, and may also cause breathing problems silicosis and skin irritation:	https://www.lenntech.com/periodic/water/silicon/silicon-and-water .
Aluminium (mg/l)	IS 10500 : 2012/ IS 260:2001	0.2 mg/L	0.03 to 0.2 mg/L	Alzheimer's Disease, affect Kidney and liver, nerve damage, allergies, and is believed to be carcinogenic	https://www.dhs.wisconsin.gov/publications/p0/p00261.pd
Phosphorous)	IS 10500 : 2012/IS 4581:1978 /IS 11744:1986	Adult 700 mg/day	1.15 mmol /lit	Affect kidney damage, osteoporosis,, Hyper-kalemia, Hyper-phosphatemia, problem of hypophosphatemia, weakening bones and teeth, liver, cardiovascular system, central nervous system (CNS), Algal growth, (http://www.ncbi.nlm.nih.gov/books/NBK109813)	http://www.nytimes.com/health/guides/nutrition/phosphorus-in-diet/overview.html
Sulphur SO ₄ ⁻²	IS 10500 : 2012/EPA	250 mg/lit (EPA Std.)	200-400mg/l	TOXIC, pulmonary edema, severe irritation, Neurological effects and behavioral changes, Disturb blood circulation, Heart damage, Effects on eyes, Reproductive failure, Damage to immune systems, Stomach/ gastro intestinal disorder, - Damage to liver/ kidney functions, Hearing defects, Disturb hormonal metabolism, Dermatological effects, Suffocation/ lung embolism	https://www.lenntech.com/periodic/elements/s.htm#ixzz4vVO87P33
Chlorine	IS 10500: 2012/WHO drinking water2017	5mg/l	250/1000 mg/l	Cancer risk of intestinal cancer, low birth-weight and premature birth, birth defects. WHO ban chlorinated drinking water 2017, Required for normal cell functions in plant and animal life.	http://apps.who.int/iris/bitstream/10665/254637/1/9789241549950-eng.pdf ,
Potassium (K)	BIS: IS: 10500, 1991	Recommend 3510 mg/day	No guide lines	Adults – blood pressure, cardiovascular disease, stroke,coronary heart disease, renal function, blood lipids, catecholamine levels. Children – blood pressure, blood lipids, catecholamine levels etc.(WHO)	http://cgwbchd.nic.in/qulstd.,www.Who.int/nutrition/publications
Calcium mg/l	IS 10500 : 2012, Recommended Diet	1000 to 1300 mg /day	75-200 mg/lit	Causes laxative effects, hyper-calcemia, Kidney stones, heart disease, Increases hardness hyperparathyroidism but act against Blood pressure and hypertension, Cardiovascular, colon and	www.who.int/water_sanitation_health/dwq/chemicals/tds . https://ods.od.nih.gov/factsheets/Calcium-

	Allowances RDAs			rectumlar disease, Cancer of the prostateisease, Bone health and osteoporosis, Preeclampsia, Wt. manage..	Health Professional/
Stannum (Sn/ tin)		0.003 to 0.03 ppm		Tin poisoning (Vomiting, diarrhea, fatigue and headache), Carcinogenicity, damage to DNA , reproductive hazards	http://www.who.int/water_sanitation_health/dwq/chemicals/tin.pdf
Iron Fe ⁺² or ⁺³ (ous or ic)	IS 10500 : 2012, IS 3025 (Part 53)	1 mg/day men and 1.5 mg/day women	0.3m g/l	For growth & metabolism, hemoglobin, myoglobin, carrier oxygen, cause anemia, maintain body temp, Make Energetic, Improves Appetite, Aids Muscle Function, Aid to Brain Dev. Ensures A Healthy Pregnancy, Enhances Immunity, Eases Restless Leg Syndrome.Relief From Premenstrual Symptoms but Fe- based enzymes. but high dose is fatal (infants) gastro intestinal system, But warning : Total concentration of manganese (as Mn) and iron (as Fe) shall not exceed 0.3 mg/l	http://www.stylecraze.com/articles/benefits-of-iron-for-skin-hair-and-health (In IS 10500/2012)
Manganese (Mn)	IS 10500 : 2012/ SMCL	50 µg/L SMCL	0.1 to 0.3 mg/l	Cause gray or black stains on porcelain, enamel, and fabrics. Can promote growth of bacterias that clog pipes and wells.	https://pubs.usgs.gov/wri/wri024094/pdf/mainbodyofreport-3.pdf

NB: All standards are from U.S. Environmental Protection Agency (1994a). MCL, Maximum Contaminant Level; SMCL, Secondary Maximum Contaminant Level; USEPA, U.S. Environmental Protection Agency, The Agency for Toxic Substances and Disease Registry (ATSDR), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA), the National Institute for Occupational Safety and Health (NIOSH)

Table 6:- The observation results of quality of heavy metals and rare earth metals of the Daya River (Monsoon and Nonmonsoon 2017)

Elements	Sunday		Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
	Non mon soon	mons oon	Non mons oon	mon soon	Non mon soon	mons oon	Non mon soon	mons oon	Non mon soon	mons oon	Non mons oon	monso on	Non mons oon	mons oon
Nonmetals and heavy metals														
Si (mg/l)	769	515.6	963.8	650	937	943	858	687	876	1064	989.6	594	961	276
P (mg/l)	607	600.6	617.9	556	659	551.2	616	536	593	547	585	551	624	550
S (mg/l)	30.6				39.3	34.4				30.5		29		
Cl (mg/l)	828	450.8	506.6	377	616	420.1	479	362	447	373	504	369	542	425
K (mg/l)	101	306.2		172	57	357.8		233		193		159		76
Ca (mg/l)	231	412.6	247.6	240	268	314.6	206	261	198	514	204	238	216	206
Ti (mg/l)	11.4	110.4	10	45	10.2	107.7		76.8		55.5		46		18.9
Mn (mg/l)	3.6	18.9	7.1	9	15.1	23.2		17.1		12.2		5.1		
Fe (mg/l)	85.3	527	98.9	198	124	468.3	38.1	332	38	390	44.8	197	38.5	102
Sn (mg/l)	54.3	52.4	55.1	57.7	57.6	58.3	59.2	44.2	58	45.8	56.4	39	44.5	50.3
Rare Earth metals														
Eu (mg/l)		7.8												
Al (%)						0.156				0.12				
H ₂ O (%)		98.04 %	99.76 %	99.1 8%	99.7 1%	98.67 %		99.13 %		99.60 %		99. 2%		99.58 %

During non-monsoon, contaminated water of the Daya River has abnormal concentration of Phosphorous, Iron, chlorine, tin and Manganese in comparison to the standards fixed by Indian standards and other global standards. Concentrations of heavy metals and nonmetals are compared for the days in a week and also during both monsoon and non-monsoon period. The comparative study indicates. Phosphorous, sulphur (3days) and chlorine can be harmful to the local person using the river water as their drinking purposes (Table 5). The conc. of iron is much above the required standard , action is pertinent for removal of iron from the water. Fe may enter the ground water and also can affect the yield of the area (Fig 6 and Tab- 6).

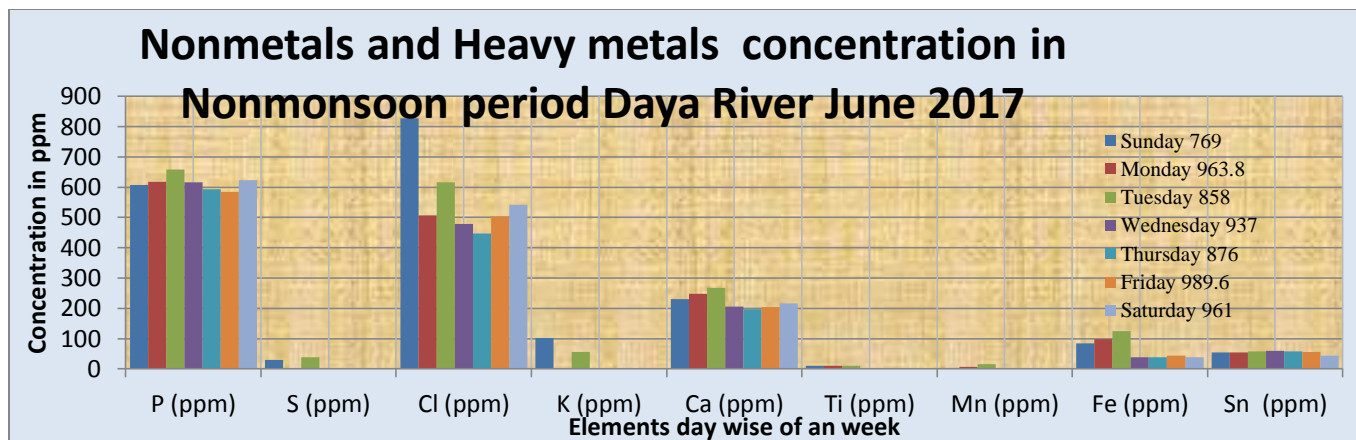


Figure 6:- Observed quantity of nonmetals and heavy metals in Daya water (Nonmonsoon) in June /2017

The concentration of Silicon dioxide in the water sample is alarming during monsoon it is due to the presence of suspended solid in water. Chlorine, Potassium, phosphorous, Iron and tin is harmful to the users downstream (Table 5). Since 99% of the effluent flows away to sea via Chilika lake with a faster speed in the river get less time to enter the ground water Table -6 and Fig – 6.

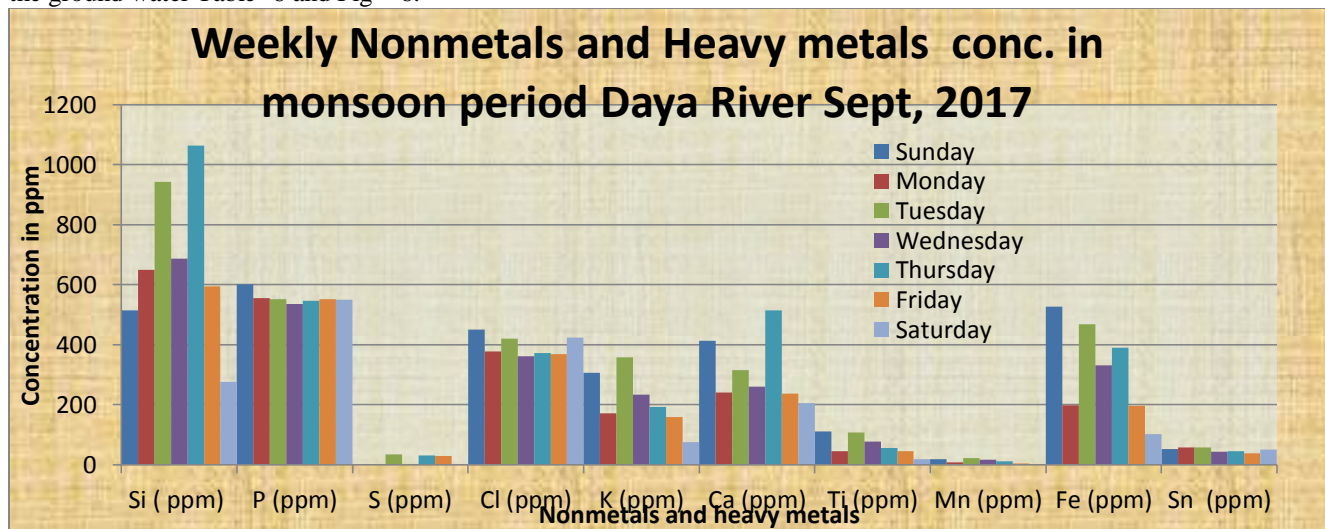


Fig 7:- Observed quantity of nonmetals and heavy metals in Daya water (monsoon) in Sept/2017

Europium (Eu) has Standard limit < 0.001% and report about biological impact not known but mildly toxic by ingestion (not established). (<http://www.lenntech.com/periodic/elements/eu.htm>) From the above data it can be concluded that there is less importance of rare earth metals present in the effluents of Bhubaneswar city liquid waste except Europium which has less impact on human health (Table 6).

Population growth and contamination of the River Daya:-

The demography of Bhubaneswar city has been considered and found that the annual growth rate have been reduced from 5.75% to 1.26% but the total population has been increased from 411542 (year 1991) to 917766 (Year 2017 estimated). The domestic liquid waste quantity has been increased. The present study is corroborated with the past reports and an assessment on increase/ decrease of the quality of the water is done for future research works. Mainly the results are compared with the Odisha Pollution control board (year 2011, 2013, 2015), (http://ospboard.org/wp-content/plugins/publication/uploads/files_1501932744_1481204503.pdf), different project reports (BMC draft plans) and works of individual researchers Mohapatra et al., 2014 and compared with the present study 2017. The comparative results for the physic chemical parameters are in Tab 7 and the heavy metals and biologic parameters during (NMS- no nmonsoon & MS-monsoon) periods are given table 7.

Table 7:- The comparative study of Physico-chemical parameters/ Nonmetals before and after confluence of Gangua drain with the River Daya

Parameter	Season	2006	2011	2013	2015	2017	2006	2011	2013	2015	2017	2006	2017
		Daya R. before Gangua Nallah					Daya R. before Gangua Nallah					Gangua nallah	
Temp (^o C).	NMS	25		28.01		30	23				32.3	20	32.3
	MS			25.5							30		29.4
PH	NMS	8.57	7.7	7.2	7.8	7.08	8.54	7.8	7.9	8.2	8.35	8.33	8.05
	Ms		7.6	7.7	7.4			7.4	7.4	7.7			
Turbidity	Av.					2			3.63				5.8
DO mg/l	NMS	6.2	6.1	4.4	6.7	7.5	9.5	6.4	5.3	6.5	14	5.8	5.2
	Ms		6.2	5.0	4.6			5.9	5.6	5.3			
BOD (mg/l)	NMS	3	2.6	3.4	3.8	3.3	7	2.7	2.9	3.3	4.66	3	5.5
	MS		3.8	4.3	4.0			3.4	3.4	2.7			
COD	NMS	10.8		8.5		2.8	14.5				2.69	8.6	6.4
	Ms			15.4									
TDS (mg/l)	NMS		147	152	187			151	152	165	251		118
	MS												
Calcium mg/l	NMS		74	79	91	193		71	77	83	224		282
	Ms					188					312		255
Chlorine	NMS		26.4	25.7	36.7	64.6	56	25.7	26.3	31	56		47
Phosphorous	NMS					5.73					6.15		6.89
	MS					5.34					5.56		5.51
Sulphur	NMS		7.9	13.09	19.7			4.5	9.81	12.9	31.4		35
	MS										30		30

N.B.: (Source data:2006: Draft plan BMC, 2011, 2013 &2015 : SPCB, Part 2013, Mahapatra et al, 2014, **2017: present study**, NMS non monsoon, MS: monsoon, otherwise stated units are in mg/l.

Table 8:- The comparative study of Physico-chemical parameters before and after confluence of Gangua drain with the River Daya

Parameter	Season	2011	2013	2015	2017	2006	2011	2013	2015	2017	2006	2017
		Daya R. before Gangua Nallah					Daya R. before Gangua Nallah					Gangua N.
Titanium mg/l	NMS									10.5		0.092
	MS									14.3		62
Manganese mg/l	NMS									8.6		10.7
	Ms				14.3							12.9
Iron (Fe) mg/l	NMS	3.92	3.98	2.17	2.53	1.8	1.66	2.93	1.60	6.69	0.36	4.31
	MS				0.48	3.0				3.16		2.87
Stannum (Tin) mg/l	NMS				0.056					0.055		0.044
	Ms				0.052					0.05		50
Silicon mg/l	NMS	6.0	5.3	5.4	919		5.1	5.54	5.4			446
	MS											515.6
Aluminum	NMS											0.138
Nickel mg/l	NMS	0.004	0.004	0.014		0.009	0.003	0.005	0.012			
	MS					0.005						
Copper mg/l	NMS	0.004	0.002	0.004		0.004	0.003	0.002	0.006		0.36	
	Ms					0.002						
Zinc mg/l	NMS	0.008	0.005	0.007		0.002	0.006	0.004	0.006			
	MS					0.006						
Lead (Pb)	NMS	0.005	0.004	0.013		0.006	0.005	0.005	0.009			
	MS					0.005						
Chromium	NMS	0.039	0.023	0.046		0.010	0.041	0.022	0.035	0.008		
	MS					0.015						
Cadmium	NMS	0.003	trace	0.0037			0.002	0.001	0.0033			

Boron	NMs	0.062	0.061	0.05			0.048	0.065	0.045			
TC	00'	NMS	269	493	749		240	70	295	1260		1100
MPN/ ml	100	MS	527	707	730			220	497	633		

N.B.: (Source data:2006: Draft plan BMC, 2011, 2013 &2015 : SPCB, Part 2013, Mahapatra et al, 2014, 2017: present study, NMS non monsoon, MS: monsoon, otherwise stated units are in mg/l.

In addition to the common element found in the river Daya, the liquid wastes of Bhubaneswar town (Gangua Nallah) contains K (2.87mg/lit), Titanium (0.092mg/l) and Tellurium (0.043 mg/lit). Similarly the river carries some heavy metals like Gadolinium (0.009mg/l), Erbium (0.07mg/l), Europium (Eu) @ 5.07mg/l and Erbium (Er) @ 0.069mg/l during non-monsoon period. But during monsoon the heavy metal Europium was found @ 0.003 mg/l and traces of Aluminum.

Remedial measures:-

Dilution of effluents reduces its provocative effect on river water and to its user downstream. The nature's cure is the best. Use of Organic manures contaminate less the river water, reduce eutrophication and boost the yield by reducing the trace metal availability. Bioremediation eliminate/ or lower the toxins in river water. The ameliorative measures to save the Water of the river Daya are:

- Identification, listing and segregation of Solid from liquid waste should be done at source from one another. Solids and liquid waste stream should be separate. Solids should be dried before reaching solid waste container.
- Segregation of liquid waste between viscous (grease, dirt etc), aqueous and organic need not be separated till they do not react with each other till final disposition with a record..
- Temporary toxic or irk pollutants collection buckets should collect wastes (but not flammable) when it is in highly concentration stage. They are to be collected from every house/ hospitals/ industries as dangerous liquid waste and daily/regularly emptied into a carboy and finally emptied into a close covered digestion tank of municipality and must be detoxicated before disposal. <http://www.ehs.washington.edu/forms/epo/label4.pdf>
- The tentative amount toxic liquid wastes generation estimated prior should be categorized as air reactive, water reactive or oxidizers and leveled and listed/updated at source.
- Coconut shell endocarp, green coconut mesocarp and sugarcane bagasse are available locally in plenty which is wasted as firewood. In commercial scale they should be used to make activated carbon fibers (ACF) and should be used to remove toxins produced by Cyanobacteria (microcystins) in the drains even.
- The samples from the waste disposed streams needs to be monitored regularly.
- Heavy metals detrimental for human health and environment of livings can be removed by Reverse Osmosis (RO) which is less cost effective. However Lime precipitation, activated carbon, silica and silica activated carbon composite, rice husk and fly ash can remove effectively Ni, Cu and Fe.
- Modern technique such as Lewatit TP 207 or Lewatit TP 208. https://www.lenntech.com/processes/heavy/heavy_metals_removal.html, can be used for reducing heavy metals in effluents. On site regeneration of acid and caustic soda can be done.
- The effect method of adsorption can be done $Fe(OH)_3$, Lennsorb 101 which can adsorb heavy metals like Cr, U, Cu, Pb, As, Sb, V, Mo and Se successfully.
- Modern method involves two types of dithiocarbamate ligands (a good binder), one aliphatic (diethyldithiocarbamate) and aromatic (diphenyldithiocarbamate), and used them in chelators for removal of Cd, Pb, Cu and Zn from adulterated water.
- Peat moss, a low cost adsorbant, like Chitin (N-acetylglucosamine, a derivative of glucose) found in the cell walls of fungi, the exoskeletons of arthropods like crabs, lobsters, and shrimps and insects, , the radulas of mollusks squid and octopuses are used for reducing heavy metals (Hg^{2+} , Cu^{2+} , Ni^{2+} , Zn^{2+} , Cr^{6+} , Cd^{2+} , and Pb^{2+}), using their chelating property **Tripathy et al , (2015)**

Conclusion:-

The monitoring of the water pollutants and ameliorative measures is highly essential for future study in the present Anthropocene epoch. To reduce the impact of the water pollution it will be better to develop large water bodies in the drainage system, manage liquid waste in a planned manner and allow the water to cure naturally.

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