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Physico-chemical, bacteriological and health hazard effect analysis of the water in Taladanda Canal, Paradip area, Odisha, India

Rabiranjan Prusty, Trinath Biswal*

Department of Chemistry Veer Surendra Sai University of Technology Burla-768018, India.

Abstract: The physico-chemical and bacteriological parameters of the water in Taladanda canal and associated water-borne diseases, from which the dwellers have suffered, were studied, by using statistical method. Overuse and the addition of the wastes with sources from urbane industrial sectors, as well as the decrease in water level have caused the canal water quality declined drastically and subsequently led to extensive eutrophication and bacterial contamination. According to the water sample analytical results, the water is lightly acidic with the pH value of 4.5~6.7. The measured indexes, such as total dissolved solid (TDS), electrical conductivity (EC), total suspended solid (TSS), Mn, Zn, Al, Fe, Cu, Cr, and Hg *etc*, mostly have very high concentrations which are higher than permissible limit, indicating that the canal water is completely unsuitable for human consumption. Furthermore, the biological analysis shows that the total coliform (TC) is in the range of 45.9~30.2 in per 100 mL water in April, 30.5~25.3/100 mL in July and 52.9~35.4/100 mL in December, respectively. Similarly, fecal coliform (FC) ranges from 12.8 to 10.1, 10.5~7.5 and 13.1~6.4 per 100 mL water in the months of April, July and December respectively. As a result, people who use the water have suffered from different water-borne diseases. On the basis of disease data derived from hospital observations in a period of three years, there had been 4 284 people affected by different water-borne diseases from 2016 to 2018.

Keywords: Water quality; Pollution; Physico-chemical assessment; Bacteriological parameters; Health hazard; Coliform; E. coli

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Introduction

The Taladanda canal is one of the most important canals, and is deemed as the water resource lifeline of both Jagatsinghpur and Cuttack districts in Paradip, Odisha. The water in this canal is used for water supply to agricultural, domestic, commercial and industrial sectors in the Paradip area (Melki *et al*. 2019; Kiss *et al*. 2019). The canal originates at Jobra of Cuttack City, where it incepts water from Mahanadi River. After flowing through Cuttack City, it separates into two parts at Biribati as Michigan canal and Taladanda canal. The Taladanda canal, with a total length of 82.3 km, is designed to be a water source for irrigation to six land blocks of the Cuttack and Jagasinghpur districts, namely Sadar Cuttack, Jagasinghpur, Balikuda, Tirtol and Ersama. Each year, the river reaches its maximum flow in June and the flow does not deplete until December. The original canal is only 13 km long from Cuttack to Biribati and 20 km long between the Kujang and Atharbanki in the district Jagatsinghpur.

The waste littering around the statue of goddess Durga and other statues during festival season has caused rigorous pollution to river Mahanadi

*Corresponding author. E-mail: biswal.trinath@gmail.com

and Taladanda canal (Pal *et al.* 2018; Prusty and Biswal, 2017). The Taladanda canal water is highly eutrified and looks black with high concentration of algae and weeds. Moreover, hazardous, toxic and infectious wastes ejected from the SCB medical college and hospital, as well as the garbage wastes from the nearby markets have been continuously added to that canal in the Cuttack Town area (Panda *et al.* 2018; Das *et al.* 2002). The presence of some dairy farms and high density of population near the canal roads also contributes pollution loads to the canal water due to the addition of animal and human excreta. The discharge of rain water from both Paradip and Cuttack City is another cause of the increase in the contamination of this canal. Paradip Town is an important port of Odisha and is highly industrialized. The town possesses a number of large-scale industries including Paradip Phosphate Ltd (PPL), SKOL Breweries, Indian Farmers and Fertilizers Cooperative (IFFCO), Indian Oil Corporation Limited (IOCL), Cargill's edible oil plant, and a number of sea fish and food processing plants *etc*. (Panigrahi *et al.* 2019; Kar and Debata, 2019). Large volume of untreated effluents from the industries, sewage from PPL Township areas and sewage water from Paradip Port Trust is the major cause of contamination of the Taladanda canal in Paradip area. The addition of agricultural effluents is another cause of eutrophication of the water in this canal.

Extensive contaminations along the canal have brought severe health hazard to not only aquatic lives, but also people residing in the village and town areas of both Jagatsinghpur and Cuttack districts. It has been evident that the major cause of health hazard effect is bacterial contamination of the surface water (Shukla *et al.* 2017). Large portion of the canal surface is covered by weeds and the fish population of the river has gradually decreased because of continuous decrease in oxygen level (Huntington *et al*. 2015). It was observed that people living in the vicinity of the canal area have been suffering from different water borne diseases such as polio, cholera, jaundice, patches, fever, and skin itching infections (Samantray *et al*. 2009; Das *et al.* 2016). There are some micro-organisms which are not responsible for producing diseases. However, these micro-organisms can cause undesirable taste and odour in the supplied water. Furthermore the presence of mainly virus helminthes, bacteria and protozoa (Duressa *et al.* 2019; Gupta *et al.* 2017) also contributes much to the water contamination. Among them, the indicator organisms E.coli and fecal coliform bacteria are the most common and popular. Table 1 represents the common diseases caused by bacteria (Mishra and Nayak, 2014; Barik *et al.* 2005; Mishra, 2010).

In this study, water samples were collected in 2019 from different locations nearby the Paradip area and various water quality parameters with bacteriological population were analyzed by adopting suitable methods. Using these data, the pollution intensity of the Taladanda canal and its health hazard effect were properly analyzed, from which some suggestions and associated recommendations have been proposed for the water management purpose.

Table 1 The disease that transmitted through the drinking water

Disease	Bacterial agent
Cholera	Vibrio cholera
Vibrios caused by gastroenteritis	Vibrio parahaemolyticus
Typhoid fever	Salmonella typhi
Bacillary dysentery or shigellosis	Shigelladysenteriae, shigellaflexneri, shigellaboydii, shigellasonnei
Gastroenteritis and acute diarrheas	Escherichia coli, particularly serotype

1 Study area

Paradip City, located at 20.16°N and 86.40°E, is one of the largest ports in the eastern coast of India (Fig. 1) and an important municipality in the coastal district of Jagatsinghpur, Odisha, India (Palei *et al*. 2014; Das *et al*. 2013). Every year, it receives and transports millions of cargos with industrial and domestic materials (Das *et al*. 2011). The area falls in tropical climate zone, with an annual temperature of about 27.0°C and annual precipitation of 1 465 mm (Hosseini *et al*. 2017;

Lultle *et al*. 2019). In average, the highest rainfall of 333 mm occurs in August, while the lowest of 122 mm occurs in December. The average highest temperature of 37°C is observed in May, which is the hottest month of the year in the Paradip Town area. The lowest average temperature in the year observed in the month of January with an average value of around 21.6°C. The economic income of the people in the district Jagatsinghpur, Odisha is mainly dependent on agriculture and fishing industry in the port trust area of Paradip. The crops cultivated in the district are sugarcane, turmeric, cotton and jute. In addition, there are many large to medium scale of industrial sectors in this district, such as Paradip Phosphates Limited, Indian Oil Corporation Limited (IOCL) Refinery, SKOL Breweries Ltd (Unit-East Coast Brewery), Cargill's edible oil plant *etc*. (Murali *et al*. 2009; Samantray *et al*. 2011).

Fig. 1 Location map of the study area

2 Materials and methods

2.1 Water sampling

Fig. 1 shows the locational map of the sampling points, where 45 water samples were collected in three different seasons (summer, winter, rainy) and preserved in clean polyethylene bottles of 100 mL from the 15 different locations along the Taladanda canal. All the samples are collected in normal weather condition at the depth of 1~2 cm below surface water level, in order to avoid floating matters, for example, oil. These samples were analyzed in the PG Department of Chemistry & Civil Engineering, VSSUT, Burla, while the bacterial analysis was done at the Institute of Life Science, Bhubaneswar.

2.2 Method for analysis of physical and chemical parameters

The parameters (DO, pH, TDS, EC, TSS, TH, Cl^-, NO_3^-, SO_4^{2-}, Alkalinity) were measured according to standard procedure available in the literature (APHA, 2005), of which UV Spectrophotometer detected the concentrations of nitrogen and sulphate in the water (ISI, 1983; Chatanga *et al*. 2019).

2.3 Procedure for analysis of metals

For measuring the contents of cation (*i.e*. Fe, Zn, Cr, Al, Hg, Cu, Mn in this case) in the water sampled, the Atomic Absorption Spectrophotometer (AAS) method was applied. It is important to measure the total suspended solids (TSS) as regard to sewage waste involved in the canal water. This was done by using standard EPA procedure of gravimetric analysis. The total hardness (TH) of the water sampled was measured by titration with EDTA solution, while the titration device was also used to determine the content of dissolved oxygen (DO) in the water. In respect of measuring the anion concentrations, Chlorimeter was used for chlorine, and correspondingly the Aquaread nitrate meter for nitrate, spectrophotometer for sulphate and fluoride meter used for the fluoride concentration in the water. Other fundamental parameters such as pH, EC and TDS were also detected by the portable equipment.

2.4 Bacteriological analysis

The bacteriological analysis in this work was carried out by using plate count method (Cabral, 2010; Mansoori *et al*. 2018), in which the bacteria are growing in a colony on a nutrient medium. For effective measurement, the original water sample must be diluted and be well arranged so that on an average bacterium colony number of between 30 and 300 can grow, for the number of colony less than 30 might cause unreliable statistical interpretation. To confirm the required number of colonies, the water samples were diluted to a series of dilutions, such as 1:10, 1:100, 1:1 000, *etc*. in sterilized water and were cultivated in the nutrient

Table 2 Water parameters, source of occurrence and effect

Parameters	Occurrence	Effect
Turbidity	Soil runoff	Cause of pathogens
Colour	Dissolved colloidal form of materials	
Odour	Degradation by bacterial community	Disagreeable odour
Electrical Conductivity	Presence of dissolved solid in water in ionic form	If the concentration of ionisable ions is high the conductivity will be more and the property of corrosion increases
pH	Because of different gas and solid materials	Cause of bitterness and corrosion of the materials
DO	Because of oxygen present in the dissolved state in water	Most corrosive gas in the environment and cause of corrosion in water and oil pipe lines, boilers, machinery parts, automobile parts
TH	Presence of chloride, sulphates and bicarbonates of Ca and Mg salts. Mostly found in some mineral present in water	Cause of decrease in foam producing capacity with soap solution
TA (Total Alkalinity)	Because of the presence of the different alkaline gases in dissolved state	Cause of embrittlement in bottom part of boiler steel
TDS	Because of the dissolved fine particles of solid materials and salts	Cause of Gastro-intestinal diseases, eye irritation and corrosion of some metals
Calcium (Ca)	Found from soap and anions of some dissolved salts.	Influencing in the dying process of textile industries

agar in a dish which then was sealed and incubated. The incubation nutrient media include plate count agar for a general count and Mac Conkeyagar for gram-negative bacteria such as E. coli and fecal coliform. After being sealed, the first set of plate was incubated at a temperature of 22°C and the second one at a temperature of 37°C for 24 hours, respectively (Gwimbi *et al.* 2019; Rai *et al.* 2019). The composition of the nutrient generally includes reagents, which can resist the growth of non-target organisms leading to the easy identification of the targeted organism due to change in color of the medium. At the end of the incubation period the colonies grown can be easily counted by naked eye within a few moments and no microscope is necessary because these are in a few millimeters across. The culture is carried out in ASTM D5465.

2.5 Statistical analysis

The people in both Cuttack and Jagatsinghpur districts have been highly dependent upon the water source in the Taladanda canal with severe water contaminations and consequent water borne diseases from which the residents have suffered. The number of people affected by different water borne diseases is represented in Fig. 2 with data collected from govt. Hospital Paradip in the year from 2016 to 2018. Statistical analysis is the scrutinizing and collection of experimental data samples from a set of items (Sentas *et al.* 2016). It formulates a model to understand how the data relates to the different underlying population.

The statistical results of various water-borne diseases the residents infected are plotted in Fig. 3, Fig. 4 and Fig. 5, from which it can be noted that the people near the Taladanda canal in the Paradip City area are highly affected by bacteriological diseases because of massive water pollution in the canal. From these figures, it can further be noted that, in the year of 2016, most people were infected by diarrhoea, salmonella, Escherichia coli, hepatitis A, and campylobacter; but that number declined in 2017 due to the public awareness of the diseases. In 2017, the number of peoples infected by cholera reached a maximum level because of less rainfall occurred in this year. In 2018, more people were affected by giardia, cryptosporidium, and dysentery, typhoid fever, of which dysentery is a common bacterium disease and typhoid fever a deadly water-borne disease.

In comparison of the water-borne disease data in the three years, it is observed that more people have been affected by typhoid disease each year than other diseases, with a minimum number of people affected by Escherichia coli. In overall, the number of people affected by different water borne diseases is in the order of typhoid > cholera > salmonella > dysentery > diarrhea > hepatitis A > campylobacter > giardia and cryptosporidium > escherichia coli 0157: H7 (E. coli).

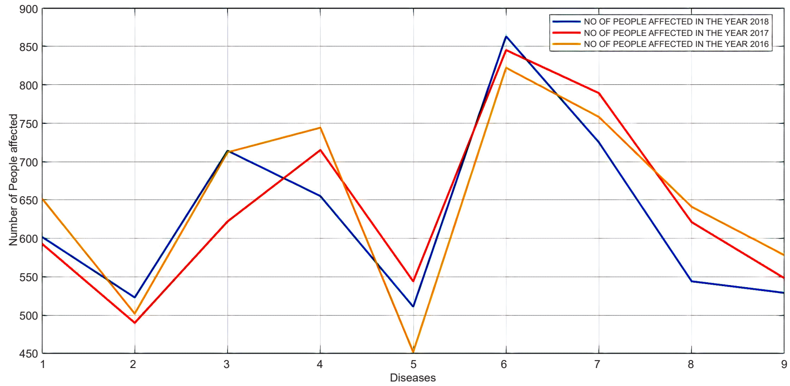

Fig. 2 Statistical graph of the number of people infected by various diseases

Data 1: The disease diarrhea; data 2: The giardia and cryptosporidium; data 3: Dysentery; data 4: Salmonella; data 5: Escherichia; data 6: Typhoid fever; data 7: Cholera; data 8: The hepatitis A; data 9: Campylobacter.

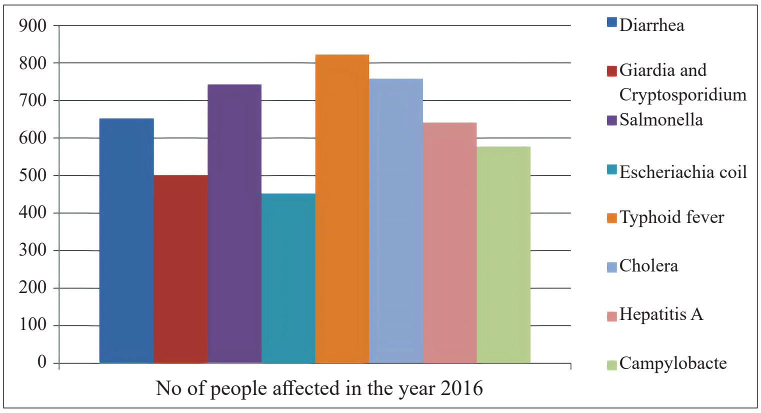

Fig. 3 Kind of diseases vs number of people affected in 2016, in which the most people affected by typhoid and the least people affected in escherichia coli, comparing with other water-borne diseases

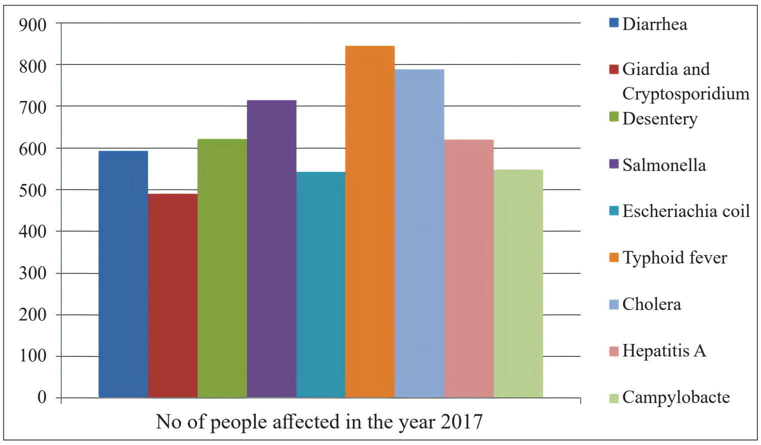

Fig. 4 Kind of diseases vs number of people affected in 2017, in which the most people affected by typhoid fever and least people by giardia and cryptosporidium

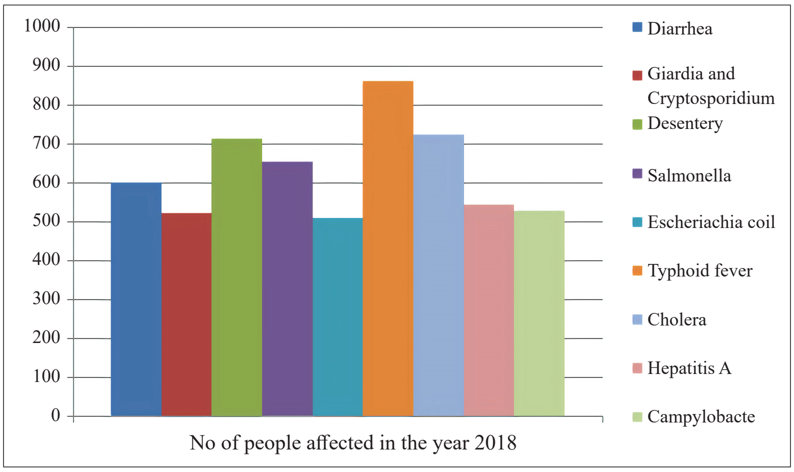

Fig. 5 Kind of diseases vs number of people affected in 2018 when the most people affected by typhoid disease and the least by escherichia coli

3 Result and discussion

From the Physico-chemical analysis with results listed in Table 4, Table 5 and Table 6, it is found that the pH of the water samples falls in the range from 4.2 to 6.7, indicating an acidic nature of the water. The DO varies from 3.6 to 5.9 which suggest a high concentration of biological matter and reduction of fish population. The values of TDS vary from 740.5 mg/L to 863.1 mg/L and the TSS from 375.1 mg/L to 452.3 mg/L, which are both extremely higher than the permissible limits. The TH, chloride, Ca, Mg are respectively within their tolerable limits. The EC values rein the range of 299 µs/cm to 319 µs/cm, being also much higher than the drinking water limit, so do the concentrations of NO_2^-, NO_3^- and SO_4^{2-}, because of the continuous addition of urban and agricultural effluents to canal. The F^- concentration varies from 0.2 mg/L to 1.9 mg/L, indicating that it is almost within the permissible limit. Except for Hg, all the concentrations of metallic contaminants such as Al, Fe, Cu, Zn and Cu are higher than the permissible limit because of addition of industrial effluents from Paradip area.

From the bacteriological analysis, it is found that the number of TC and FC per 100 mL is comparatively higher in winter and summer seasons than the rainy season because of drastic decrease in the level of the canal water, which suggests that the water is unsuitable for human consumption. The maximum value of TC (as 52.9 MPN/100 mL) was largely observed at Paradip port area in the month of December (winter), with a minimum (26.5 MPN/100 mL) during rainy season (July) in Tirtol area.

4 Conclusions

The presence of high concentrations of TDS, TSS and EC and high microbial contents such as TC and FC bacteria show degradation in water quality of the Taladanda canal in and around the port city Paradip, Odisha, India. Since the water of this oldest canal of Odisha is consumed by both rural and urban communities of both Cuttack and Jagatsinghpur districts, its standard value of physico-chemical and bacteriological parameters must have to be restored. It is the cause of many diseases and hazards to the biological community. This study is carried out to reveal the physicochemical and bacteriological characteristics of the Taladanda canal in three different seasons (summer, rainy and winter) around the port city of Odisha (Paradip) with different kind of diseases produced with statistical analysis data. It is revealing that most of the physical and chemical parameters are much higher than the prescribed desirable limits and the water of this canal is acidic in nature. The PPL, NO_3^- and PO_4^{3-} are high in the Paradip Town area. The TDS and TSS values are exclusively higher than normal and the water is highly eutrified. Thus, the water in this canal is totally unfit for human consumption. Because of high values of NO_3^- and PO_4^{3-} in the Taladanda canal near to the Paradip City, the water of this

Table 3 Bacteriological analysis of drinking water samples in the Paradip City

Water samples collected at different areas of Paradip City	MPN test in April-2018		MPN test inJuly-2018		MPN test in December-2018	
	TC Bacteria/ 100 mL	FC Bacteria/ 100 mL	TC Bacteria/ 100 mL	FC Bacteria/ 100 mL	TC Bacteria/ 100 mL	FC Bacteria/ 100 mL
S1	38.2	10.1	25.3	9.2	45.2	10.2
S2	44.4	12.4	29.3	8.8	39.1	11.2
S3	42.5	11.3	31.4	8.5	35.4	10.5
S4	42.2	10.5	30.4	8.7	36.2	12.1
S5	45.9	11.2	30.5	9.9	37.5	11.3
S6	45.6	11.5	31.1	9.2	44.1	10.2
S7	30.2	11.2	32.1	9.6	36.1	10.5
S8	48.5	10.6	26.4	9.1	41.2	11.5
S9	32.4	10.7	29.5	8.2	40.2	8.4
S10	32.2	10.5	25.6	8.1	41.6	7.9
S11	32.2	10.4	26.5	8.5	40.5	6.4
S12	40.3	11.2	26.4	7.9	45.6	10.4
S13	35.5	10.4	26.3	7.5	46.2	6.5
S14	34.2	11.4	28.9	9.5	46.2	7.6
S15	52.4	12.8	26.6	10.5	52.9	13.1

Table 4 Analysis of physico-chemical parameters in April, 2018

Parameters	Water samples collected in Paradip City during first series														
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
Temperature (°C)	20	19	18	19	19	20	19	19	19	18	18	20	19	21	18
Colour	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Odour	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL
pH	6.7	6.6	6.5	6.2	6.5	6.5	6.4	6.4	6.5	6.3	6.4	6.6	6.5	6.6	6.4
EC (μs/cm)	311	318	312	311	314	311	315	314	316	319	317	318	314	316	317
TDS (ppm)	751.2	754.2	759.4	752.6	758.6	745.2	746.2	749.2	746.5	742.3	750.1	760.4	764.4	741.2	740.5
TSS (mg/L)	375.1	378.4	382.1	384.1	389.1	377.4	378.2	389.1	389.4	398.4	385.4	387.8	398.4	388.4	385.4
TH (ppm)	48	38	47	49	31	37	37	31	52	53	46	43	54	47	59
Ca (mg/L)	32	40	44	48	32	44	40	27	44	40	40	55	44	48	44
Mg (mg/L)	24	27	30	30	28	35	41	26	17	15	17	30	37	40	27
Cl (mg/L)	46	34	40	29	32	31	30	37	35	38	31	40	41	31	37
DO (mg/L)	4.9	4.5	4.7	5.9	5.01	4.2	4.9	4.8	4.7	4.6	4.8	4.7	4.4	5.1	5.1
NO_2^- (mg/L)	28	29	28	25	36	35	41	28	36	3.9	29	32	38	27	31
NO_3^- (mg/L)	30	50	30	20	30	30	45	58	35	50	50	40	20	20	48
SO_4^{2-} (mg/L)	25	24	32	24	35	24	25	29	27	26	24	28	24	26	26
Alkalinity	100	150	200	150	150	100	150	150	120	120	100	100	120	100	100
Mn (mg/L)	0.1	0.3	0.4	0.8	0.5	0.2	0.4	0.7	0.8	0.8	0.5	0.6	0.1	0.4	0.4
Zn (mg/L)	0.3	0.2	0.1	0.2	0.5	0.4	0.2	0.8	0.2	0.3	0.1	0.6	0.4	0.3	0.1
Al (mg/L)	0.2	0.2	0.1	0.1	0.01	0.3	0.1	0.2	0.1	0.3	0.1	0.3	0.2	0.5	0.1
F (mg/L)	1.5	0.2	0.2	0.8	0.5	2.4	1.7	1.5	1.9	0.2	0.2	1.8	0.6	1.5	1.2
Fe (mg/L)	0.9	0.6	0.8	0.5	0.9	0.9	0.6	0.9	0.1	0.1	0.5	1.2	0.9	1.6	1.4
Cu (mg/L)	0.2	0.5	0.1	0.2	0.5	0.9	0.2	0.2	0.4	0.5	0.1	0.1	0.9	0.3	1
Cr (mg/L)	0.1	0.5	0.5	0.1	0.3	0.3	0.2	0.1	0.3	0.1	0.3	0.1	0.2	0.2	0.1
Hg (mg/L)	0.01	0.03	0.02	0.01	0.04	0.03	0.01	0.02	0.03	0.02	0.02	0.01	0.03	0.02	0.01

Table 5 Analysis of physico-chemical parameters in July, 2018

Parameters	Water samples collected in Paradip City during second series														
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
Temperature (°C)	21	18	21	20	17	22	18	21	22	19	19	20	19	17	21
Colour	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Odour	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL
pH	6.4	5.3	5.2	5.5	5.2	5.1	4.9	4.6	5.2	4.8	4.5	5.1	4.6	5.1	5.3
EC (μs/cm)	299	306	305	300	301	302	304	307	304	304	302	304	303	299	300
TDS (ppm)	850.1	863.5	846.2	851.3	831.2	825.1	851.2	831.4	862.1	843.2	856.4	854.5	859.4	863.1	839.1
TSS (mg/L)	423.2	452.3	421.6	413.2	411.2	429.5	427.4	425.2	427.1	426.1	411.2	419.4	416.2	418.5	417.2
TH (ppm)	27	26	31	28	26	21	27	29	24	24	25	23	21	24	28
Ca (mg/L)	36	44	32.6	52	38	55	40	32	28	32	35	32	28.5	36	30
Mg (mg/L)	30.1	35	30.1	26	40	25	27	32	33	19	30	27	34	28	25
Cl (mg/L)	19	31	24	21	20	25	26	21	19	23	24	25	26	21	19
DO (mg/L)	5.1	5.2	5	3.7	3.6	3.5	3.4	4.9	4.5	4.7	4.5	4.3	4.2	4.1	4.2
NO_2^- (mg/L)	35	32	30	26	35	52	42	37	27	25	50	35	42	42	40
NO_3^- (mg/L)	24	26	25	30	45	48	41	46	48	43	35	38	35	31	34
SO_4^{2-} (mg/L)	25	19	32	18	35	21	25	18	27	26	24	15	19	21	26
Alkalinity	150	120	120	100	100	120	100	100	100	150	200	150	150	100	130
Mn (mg/L)	0.1	0.2	0.5	0.8	0.7	0.2	0.4	0.7	0.4	0.7	0.5	0.6	0.1	0.3	0.4
Zn (mg/L)	0.3	0.4	0.1	0.2	0.4	0.4	0.2	0.7	0.2	0.6	0.1	0.6	0.4	0.3	0.1
Al (mg/L)	0.6	2.3	1.1	0.6	0.8	1.1	1.6	1.2	1.1	0.2	0.8	0.6	0.7	1	1.2
F (mg/L)	1	0.5	0.3	0.9	0.8	1.2	1.1	0.7	1.2	0.3	0.9	0.8	0.8	0.8	1
Fe (mg/L)	0.1	0.1	0.1	0.2	0.1	0.3	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cu (mg/L)	0.1	0.4	0.1	0.2	0.5	0.9	0.3	0.2	0.6	0.5	0.1	0.1	0.9	0.3	1.0
Cr (mg/L)	0.1	0.5	0.5	0.1	0.3	0.3	0.2	0.1	0.3	0.1	0.3	0.1	0.2	0.2	0.1
Hg (mg/L)	0.02	0.03	0.02	0.02	0.04	0.03	0.01	0.02	0.03	0.01	0.02	0.01	0.03	0.02	0.01

Table 6 Analysis of physicochemical parameters in December, 2018

Parameters	Water samples collected in Paradip City during third series														
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
Temperature (°C)	20	19	18	19	19	20	19	19	19	18	18	20	19	21	18
Colour	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Odour	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL
PH	4.5	4.6	4.2	5.2	4.8	4.9	5.3	4.6	4.5	5.1	5.3	4.9	6.2	5.9	5.4
EC (μs/cm)	301	305	303	302	305	306	312	311	310	314	315	311	309	308	314
TDS (ppm)	700.4	709.1	720.6	700.1	710.6	708.4	709.5	707.7	709.2	712.5	720.4	711.6	713.4	711.5	718.6
TSS (mg/L)	351.6	345.6	340.2	346.4	351.5	360.4	342.6	349.2	339.5	347.6	346.7	340.8	353.4	351.4	350.4
TH (ppm)	26	24	31	29	26	21	27	29	24	24	25	23	26	24	28
Ca (mg/L)	32	40	44	48	32	44	40	27	44	40	40	55	44	48	44
Mg (mg/L)	24	27	30	30	28	35	41	26	17	15	17	30	37	40	27
Cl (mg/L)	106	78	99	106	72	78	90	106	90	78	78	90	108	150	110
DO (mg/L)	5.8	5.9	5.8	4.5	5.6	5.5	5.0	5.8	5.6	5.9	5.9	5.2	5.8	5.7	5.3
NO_2^- (mg/L)	30	50	30	20	30	30	45	58	35	50	50	40	20	20	48
NO_3^- (mg/L)	120	120	120	100	120	100	120	80	80	100	115	90	90	120	110
SO_4^{2-} (mg/L)	100	150	200	150	150	100	150	150	120	120	100	100	120	100	100
Alkalinity	100	100	150	200	150	150	100	130	150	120	120	100	100	120	100

Table 6 (Continued)

Parameters	Water samples collected in Paradip City during third series														
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
Mn (mg/L)	0.3	0.2	0.5	0.7	0.7	0.2	0.4	0.7	0.2	0.7	0.5	0.6	0.1	0.3	0.4
Zn (mg/L)	0.3	0.4	0.1	0.2	0.4	0.4	0.2	0.7	0.2	0.5	0.1	0.6	0.4	0.3	0.1
Al (mg/L)	1.5	0.2	0.2	0.8	0.5	2.4	1.7	1.5	1.9	0.2	0.2	1.8	0.6	2.5	1.9
F (mg/L)	0.9	0.6	0.8	0.5	0.9	0.9	0.6	0.9	0.1	0.1	0.5	1.2	0.9	1.6	1.4
Fe (mg/L)	0.2	0.5	0.1	0.2	0.5	0.4	0.2	0.4	0.5	0.7	0.1	0.6	0.7	0.3	1
Cu (mg/L)	0.1	0.3	0.1	0.2	0.4	0.9	0.3	0.2	0.7	0.5	0.1	0.1	0.8	0.3	1
Cr (mg/L)	0.2	0.5	0.4	0.1	0.3	0.3	0.2	0.1	0.2	0.1	0.3	0.1	0.2	0.2	0.1
Hg (mg/L)	0.02	0.04	0.02	0.02	0.05	0.03	0.01	0.01	0.03	0.01	0.02	0.01	0.05	0.02	0.07

canal is highly eutrified resulting the production of much higher concentration of algae. Hence it is recommended to the government that the Taladanda canal should be cleared periodically, at least two times in a year with the testing of E. coli and Coliform bacteria. Necessary steps have to be taken towards the restoring the water quality of this old and important canal of Odisha, so that the people residing near it will benefit.

Recommendation and remedial measures

(1) The public health significance of water quality cannot be over emphasized. The quality of water in Taladanda canal is changing in response to seasonal, climatic condition, human activities and many other factors. Monitoring of water quality parameters of this old canal is highly crucial because a change in the quality of water adversely affects the consumers and such type of contaminated water will cause health hazard problems.

(2) Regular Physico-chemical and bacteriological analysis of water in the Taladanda canal for the source should be carried out to determine the usability of the water by the dwellers.

(3) Assessment of water not only reveals the severity of specific impurities, but also indicates the likelihood of other contaminants being present in it. Hence periodical analysis of the water quality of Taladanda canal has to be done and on the basis of that report and proper steps have to be adopted to decrease the pollution load.

(4) The rural communities living near by the Taladanda canal used untreated water of this canal for drinking and other domestic purposes, therefore proper investigations of water quality before consumptions are necessary for minimization of health problems.

(5) The quality of water is directly linked to the quality of our lives. By supporting clean initiatives and similar measures we can improve our water treatment systems, leading to ensuring for having clean, safe water for ourselves, our families and our communities. Hence, before the water from Taladanda canal is used for drinking, it should be properly treated.

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