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Physio-Chemical and Biological Analysis of Radaur-Ladwa Stretch (Western Yamuna Canal)

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ABSTRACT

This paper deals with the suitability of Surface and Ground water quality of Western Yamuna Canal in Haryana, India for irrigation and other use. The major water use of this canal is for irrigation purpose (94%), domestic water use (4%) and industrial and other uses (2%).The rapid increase inurbanization and industrialization is leading towards deterioration of water quality. In this study, analysis is performed to identify the groundwater and surface water quality in the vicinity of Radaur-Ladwa stretch. Direct disposal of domestic and industrial wasteobstructs the flow of Western Yamuna Canal thus water is stagnant at most places and self-purification mechanism of water is occurring no more. This study reveals that the surface water of the Western Yamuna Canal comes under E class of water, which is unfit for domestic use, propagation of wildlife and fisheries. However it is found suitable for irrigational and industrial cooling purpose only. Most Probable Number (MPN) values are high in the ground water, which indicates microbial contamination of water and require immediate action for up-grading existing treatment facilities.The result indicates alarming signs and suggests immediate response for policy along with adaptation and mitigation to bring at full stop to contaminating activities. If water contamination is continued likewisea time will come soon that the water qualityof Radaur-Ladwa stretch (Western Yamuna Canal) will be unfit for irrigational purpose too.

Keywords: Physio-chemical parameters;Biological parameters;Western Yamuna canal;Radaur-Ladwa stretch; BOD; COD; pH

INTRODUCTION

River Yamuna is the largest tributary of the River Ganga. The main stream of the river Yamuna originates from the Yamunotri glacier near Bandar Punch (38° 59' N and 78° 27' E) in the Mussourie range of the lower Himalayas at an elevation of about 6,320 meter above mean sea level in the district Uttarkashi (Uttarakhand). The catchment of the Yamuna river system covers parts of the states of Uttaranchal, Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh and the entire state of Delhi. The river Yamuna traverses a distance of about 1,370 kms in the plain from Saharanpur district of Uttar Pradesh to the confluence with river Ganga at Allahabad (Paliwal, 2001). The Yamuna River has four main tributaries in the Himalayan region: RishiGanga, Hanuman Ganga, Tons, and Giri; in the plains, the main tributaries are the Hindon, Chambal, Sind, Betwa and Ken and these together contribute 70.9% of the catchment area and balance 29.1% is the direct drainage of main river and smaller tributaries. The river Yamuna enters in Haryana at Yamuna Nagar district with forming the eastern boundary to the neighbouring Saharanpur district. This boundary is also a state boundary, as Saharanpur is in the state of Uttar Pradesh. The district also separates the Yamuna system from the Sutlej river system (MEF, 2010).

As per Central Pollution Board, water of Yamuna abstracted for various uses such as irrigation (94%), domestic water supply (4%) and industrial and other uses (2%). Table 1.1 shows the canal derived from River Yamuna. The purpose ofconstructing these canals were providing appropriate amount of water for agriculture and industries to full fill their requirements (Central Pollution Control Board, New Delhi,CPCB 2006).

Western Yamuna canal: Western Yamuna Canal off taking from river Yamuna was constructed in 1335 A.D during Feroj Shah Tughlaq's rule but it ceased to flow in 1750 due to excessive siltation. Government of India appointed Mr. G.R. Blane, an engineer of Bengal in 1817 to restore old Mughal canal. The canal was de-silted and renovated during a period of 3 years. There were no permanent headworks constructed on river Yamuna. The supplies in canal varied with the seasonal variation in the flow of river. The famine of 1832-33 led to remodelling of the canal and construction of weir on Yamuna at Tajewala and a low masonry dam at Dadupur and Somb torrent about 19.2 km downstream of Tajwala during 1875-79(Kazmi 2000).

The Sirsa branch, the largest branch canals of western Yamuna canal was constructed during 1889-1895. The system was extensively remodelled and extended during 1940-43.In order to tackle the problem of excessive entry of silt and also from

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Table 1: Canals derived from river Yamuna

Canal	Origin	Capacity	Area (Hactares)	State
Western Yamuna canal	Right bank of River Yamuna at Hathnikund/Tajewala barrage	163 m^3/sec	486,000	Haryana
Eastern Yamuna canal	Right bank of River Yamuna at Hathnikund/Tajewala barrage	85 m^3/sec	191,000	Uttar Pradesh
Agra canal	Right bank of River Yamuna at Okhla barrage	63.5 m^3/sec	138,000i	Two districts of Mathura and Agra in Uttar Pradesh
Gurgaon canal	Takes off from Agra canal at a distance of around 8 km from its off take at Okhla barrage	14.15 m^3/sec	40,000	Interstate project between Rajasthan and Haryana

Source: CPCB 2006

safety point of view; Government of India in consultation with Haryana and Uttar Pradesh decided to replace the old Tajewala head works with modern Hathnikund Barrage across river Yamuna upstream of the existing Tajewala headworks. The barrage has 10 bays of 18m size. A link canal has been constructed to link the Hathnikund barrage with the existing canal off taking from the weir. The WesternYamuna Canal main canal is 82km long with head discharge capacity of 452.8m^3 (Paliwal, 2001).

Site Description

Radaur is a town in Yamuna Nagar district in the Indian state of Haryana. It is located on the Yamuna Nagar to Karnal road, and is also close to the towns of Kurushetra,Shahbad and Ladwa. It is on the bank of Western Yamuna Canal. As of 2001 India census, it had a population of 11,737. Radaur is very old town. There are lots of old houses in town, which were built before partition of India. The detailed explaination of the sampling sites is provided in Table 2 and Figure 1.

Ladwa is a city and a municipal committee in Kurukshetra district in the Indian state of Haryana. In 2007, Ladwa became a VidhanSabha and come under Kurukshetra (LokSabha constituency). It is located on the Kurukshetra - Yamunanagar - Saharanpur road and is also close to the towns of Shahbad, Radaur and Indri. The nearest major Highway is National Highway 1 known as Grand Trunk Road which is14.5 km west direction of downtown. Ladwa has one of the best new grain markets in all over Asia. As of 2001 India census, it had a population of 22,439. In Ladwa, there arefew small industries mostly rice mills. Radaur-Ladwa stretch is full with greenery, but due to urbanization, pollution is increasing in this stretch. Some industries like rice industries, sugar industries and other are developing. Pollution in this stretch is not due to this region but, it is coming through its neighbour places. Water of Western Yamuna Canal is mainly used for irrigation purposes as well as for domestic and industrial purposes.

The stretch is being taken for the study is given in Table 2 and Figure 1. All ground water samples were collected within 1-2 km distances and distance between all surface water sampling stations were 3-5 km. Sampling was done in the month of January-February 2014in accordance with(Kazmi, 2000).

Table 2: Nomenclature used for sampling stations

S. No.	Sampling station	Location	Sample code	Depth
1.	Surface water (Western Yamuna Canal)	Badarpur	WYC01	-
	Ground water (tube well)	Near Badarpur	TW02	100 ft
2.	Surface water (Western Yamuna Canal)	Dhanaura bridge	WYC03	-
	Ground water (tube well)	Near Dhanaura bridge	TW04	80 ft
3.	Surface water (Western Yamuna Canal)	Radaur	WYC05	-
	Ground water (tube well)	Near Radaur	TW06	95 ft
4.	surface water (Western Yamuna Canal)	Khurdi	WYC07	-
	Ground water (tube well)	Near Khurdi	TW08	90 ft
5.	surface water (Western Yamuna Canal)	Sukhpura	WYC09	-
	Ground water (tube well)	Near Sukhpura	TW10	100ft

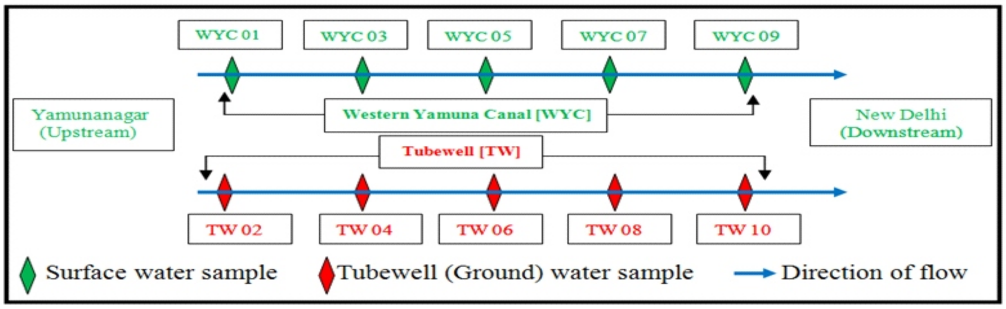

Fig1: The linearized diagram of the samples from Western Yamuna Canal stretch

Parameter Analysis

Various impurities present in water samples of this study is expressed through physio-chemical parameters such as pH, Colour, Chlorides, Total Dissolved Solids (TDS), Alkalinity, Electrical Conductivity, Acidity, Temperature, Turbidity, Hardness and Chemical Oxygen Demand (COD) and Biological parameters such as biochemical oxygen demand (BOD) andmost probable number (MPN)/Coliform(Berck, 1987).

MATERIALS AND METHODS

All experiments are performed according to the standard procedure (Lenore *et al.*, 2005) and all standards are taken as per Indian standards (Bureau of Indian Standard IS: 2490, Part-I-1981 and Bureau of Indian Standard IS: 10500:1991).

RESULTS AND DISCUSSIONS

The characteristics of ground water samples at different distances from Radaur-Ladwa stretch and surface water samples from the River Yamuna (Western Yamuna Canal) has been analysed and studied. The physio-chemical and biological parameter analysis is done as per the Standard methods for the examination of water and wastewater. The distribution of various chemical constituents in various samples is discussed as(Kazmi 2000).The classification of water for various purposes or uses based on quality criteria as per CPCB is mention in Table 3.

Table 3: Classification of Water as Per Quality Criteria (CPCB, 2003)

Designated-best-use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	Total Coliforms Organism MPN/100 ml shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6mg/l or more Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing	B	Total Coliforms Organism MPN/100 ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	Total Coliforms Organism MPN/ 100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more Biochemical Oxygen Demand 5 days 20°C 3m
Propagation of Wild life and Fisheries	D	pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more Free Ammonia (as N) 1.2 mg/1 or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	pH between 6.0 to 8.5 Electrical Conductivity at 25°C micro mhos/cm Max.2250 Sodium absorption Ratio Max. 26 Boron Max. 2mg/l
	Below-E	Not Meeting A, B, C, D & E Criteria

A. Electrical Conductivity (pH)

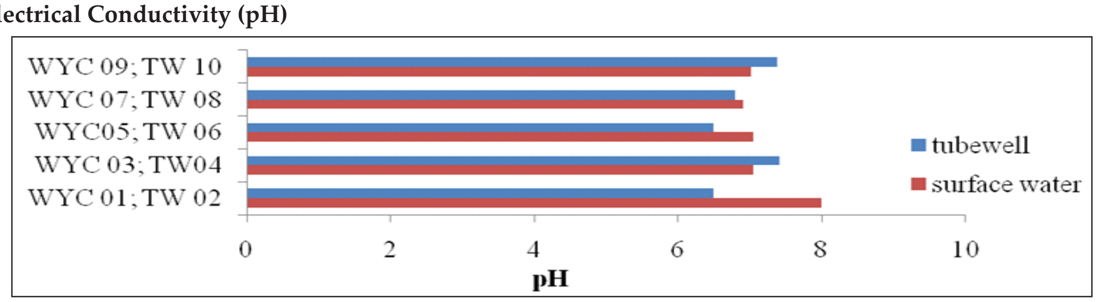

Fig.1: Graphical representation of pH

The pH values of various water samples in Figure 1are in the range of 6.9 to 8.0. According to Indian standards, value of pH for potable water should be in the range of 6.5 - 8.5 and for irrigation purpose pH of water must lie in the range of 5.5 to 9. The result shows that pH of all water samples lie in this range.

B. Alkalinity

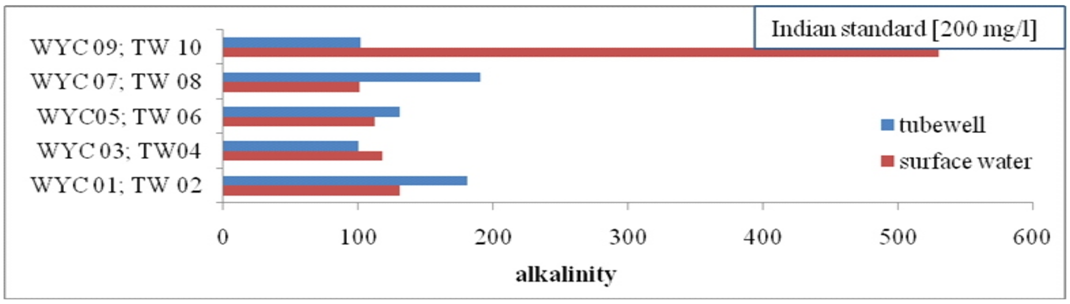

Fig. 2: Graphical representation of Alkalinity

According to WHO and BIS standard, the limit of alkalinity in portable water should be 200 mg/1 whereas the maximum limit is up to 600 mg/1. The value of alkalinity of various water samples in figure 2 is found in the range of 101 to 530 mg/1which lies in desirable range except for WYC09 that is 550 ml/l.

C. Acidity

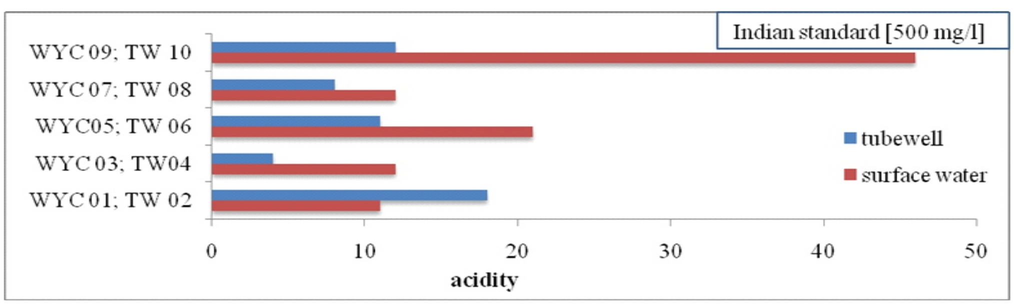

Fig. 3: Graphical representation of Acidity

The acidity of various water samples in figure 3 are found in the range of 11 to 46 mg/1. According to WHO and BIS standard, the limit of acidity in drinking water is 500 mg/1 and results of acidity of all water samples lie in this range except for WYC09 that is 450 mg/l.

D. Total Dissolve Solids (TDS)

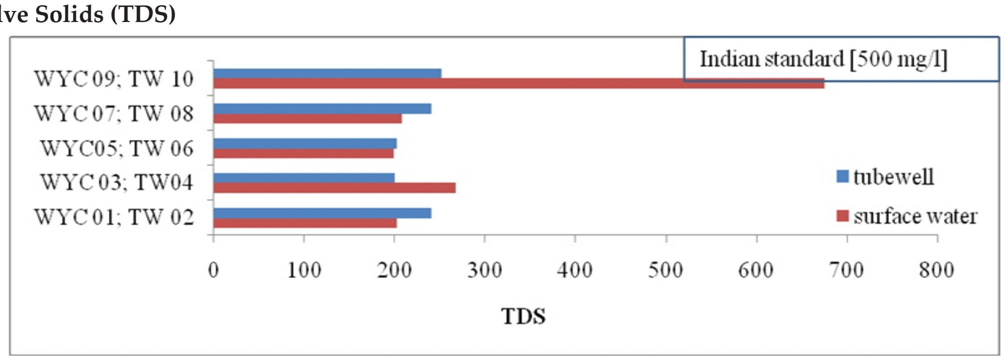

Fig. 4: Graphical representations of Total Dissolve Solids (TDS)

TDS concentration as shown in figure 4 of water samples were found in the range of 198.25 to 674.05 mg/l. As per WHO and BIS, prescribed permissible limit for the TDS is 500mg/l to 2000mg/l for drinking water and result of all water samples lie in this range except for Sukhpura station (WYC09). The reason behind this is due to directly disposal of waste from various sources between WYC 07 and WYC 09. High TDS is because of high amount of organic waste and nitrate in water body. It increases the microbial growth(Pacheco *et al.,* 1997; Misra, 2005).

E. Chlorides

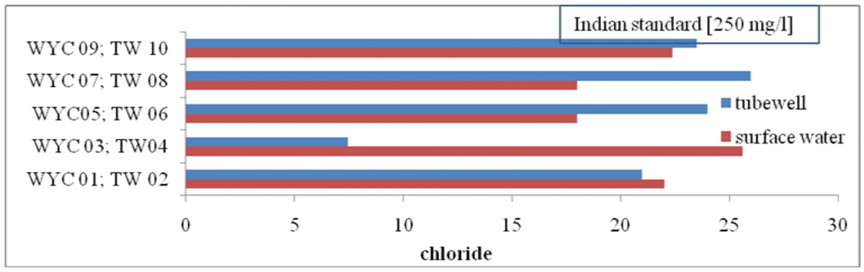

Fig. 5: Graphical representation of Chloride

Concentration of chloride in all water samples in figure5ranged 18 to 25.6 mg/1. According to WHO and BIS standards the prescribed limit for the Chlorides is 250 mg/1 to 1000mg/l and all water samples lay in between this range except for TW08 and WYC03 because of high waste dumping and discharge in the area.

F. ElectricalConductivity

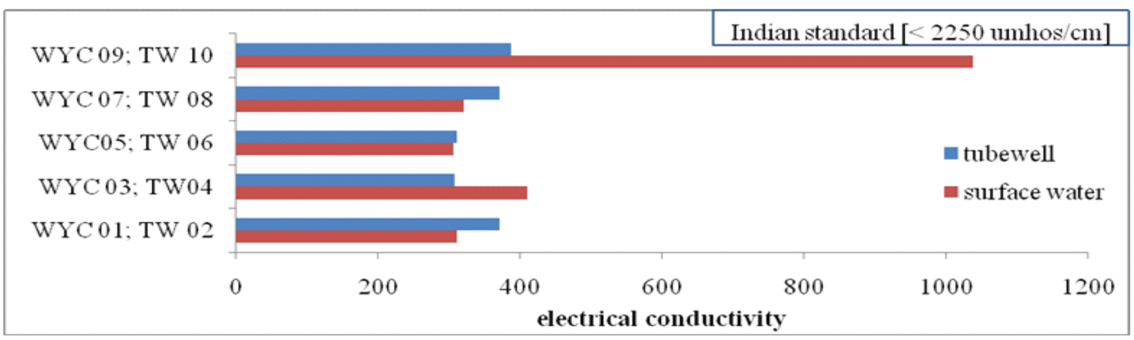

Figure 6: Graphical representation of Electrical Conductivity

Concentrations of Electrical Conductivity in all water samples in figure 6 are in range from 305-1037 umhos/cm. As per WHO and BIS standard the prescribed limit for the Electrical Conductivity is less than 2250 umhos/cm and all water samples lie in between this rangeexcept for sampling station WYC09 because of various polluting sources between WYC 07-WYC09.

Conductivity is the capacity of water to carry an electrical current and varies both with number and types of ions in the solutions, which in turn is related to the concentration of ionized substances in the water. Most dissolved inorganic substances in water are in the ionized form and hence contribute to conductance. When electrical conductivity in water is higher than the prescribed range, the irrigated soil becomes more alkaline and get deteriorated that means soil becomes uncultivable (Vengosh *et al.,* 1994).

G. Hardness

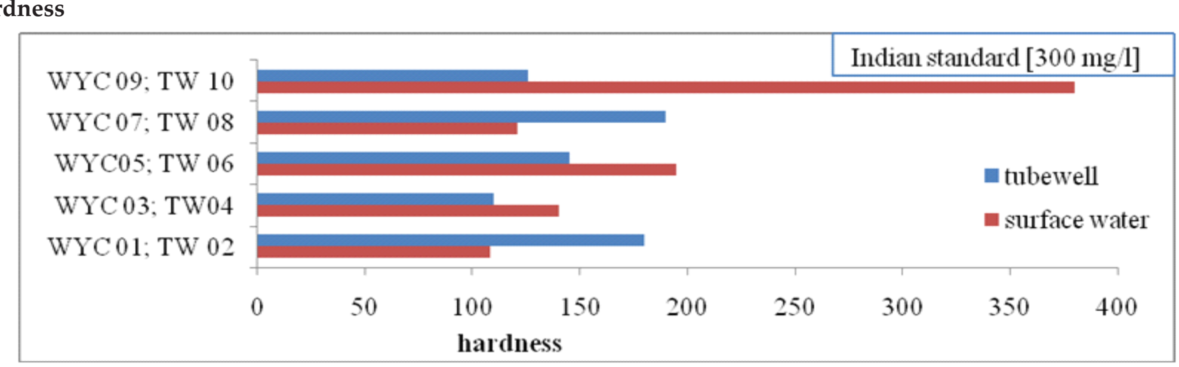

Fig. 7: Graphical representation of Hardness

Hardness found in all water samples in figure 7 are in the range of 110 to190 mg/l. According to WHO and BIS standard, the limit of hardness in drinking water is 300 mg/l while the maximum limit is up to 600mg/1 and all ground water samples lie in between this range. In general, hardness is of little public health significance. In ground water the hardness is mainly due to the presence of hydroxides (OH), carbonates (CO3), bicarbonates (HCO3-) and sulphates. Excess of hardness causes the scale formation in boilers and sometime its cause stone formation in human parts.

H. Turbidity

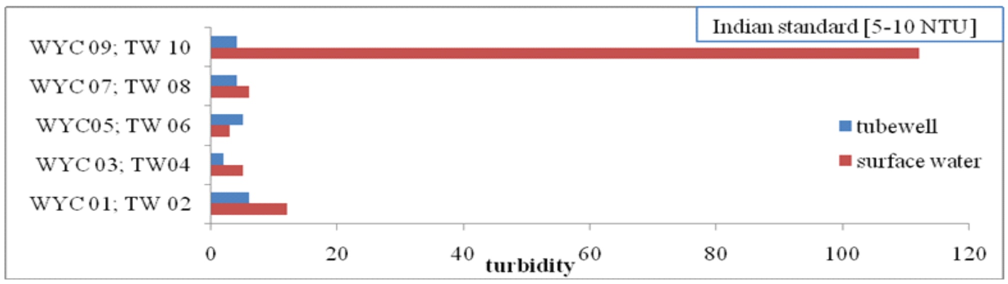

Fig. 8: Graphical representation of Turbidity

Turbidity found in all water samples in figure 8 were in the range of 12 to 112 NTU. As per the WHO and BIS standard, the limit of turbidity in portable water is 5 NTU, while the maximum limit is up to 10 NTU and all surface water samples lie in between this range except surface water sample no.WYC09, this is possible due to seepage of water from sewer lines or direct sewage waste water discharge at this site and at previous site.In ground water and surface water turbidity is mainly due to the presence of organic matter. Excess of turbidity causes the bacterial growth in ground water and surface water.

I. Biological Oxygen Demand (BOD)

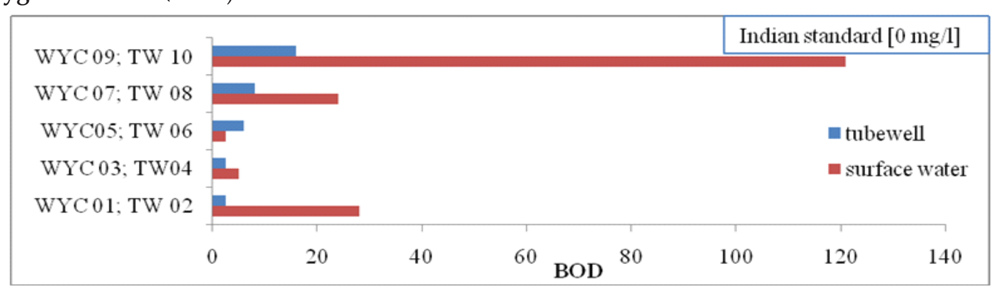

Fig.9: Graphical representation of Biological Oxygen Demand (BOD)

The concentration of BOD for most of the water samples in figure 9are in the range of 5 to 121 mg/l, which is possible due to seepage of water from sewer lines or direct waste discharge. Almost all the samples are at the highly polluted the highest polluted sample is obtained from WYC 09.The results suggest that the water of WYC is not even fit for discharge into the main stream of river Yamuna. As per Central Pollution Control Board the permissible limit for surface water is at least up to the bathing standard BOD ≤ 3.0 mg/l.

The concentration of BOD for most of the groundwater samples were in the range of 3 to 16 mg/l. The general trend of BOD seen in ground water samples is in such a manner that the sample obtained near the surface water source had higher BOD values than the points away from surface water source, which can be result of seepage of stream water into nearby groundwater. As per Central Pollution Control Board the permissible limit for ground water is 0 mg/l i.e. no BOD. Hence, all of the ground water samples have high BOD than permissible limit so it is unfit for drinking.Increase in BOD value denotes the Increase in microbial population and increased level of pollution in water resulting in spread of diseases in human and animals equally (Berck, 1987).

J. Chemical Oxygen Demand (COD)

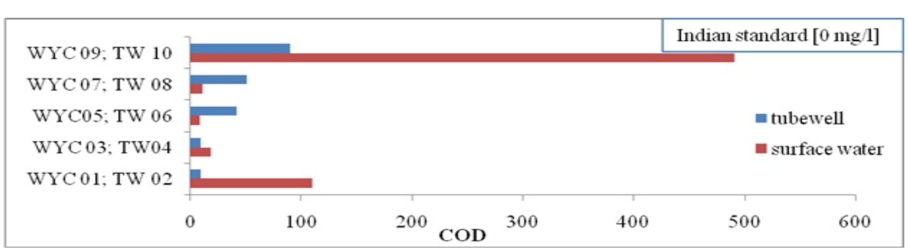

Fig. 10: Graphical representations of Chemical Oxygen Demand (COD)

The concentrations of COD for most of the water in figure 10 are in the range of 2 to 491 mg/l. As per Central Pollution Control Board the permissible limit for surface water is COD ≤ 250.0 mg/l. Results of samples of water are greater than this limit. This may become possible due to seepage of water from sewer lines or direct sewage wastewater discharge.

The concentration of COD for most of the groundwater samples were in the range of 3 to 90 mg/l. As per Central Pollution Control Board the permissible limit for ground water is 0 mg/l i.e. no COD. Hence, all of the ground water samples have high COD than permissible limit so it is unfit for drinking.

K. Coli-form

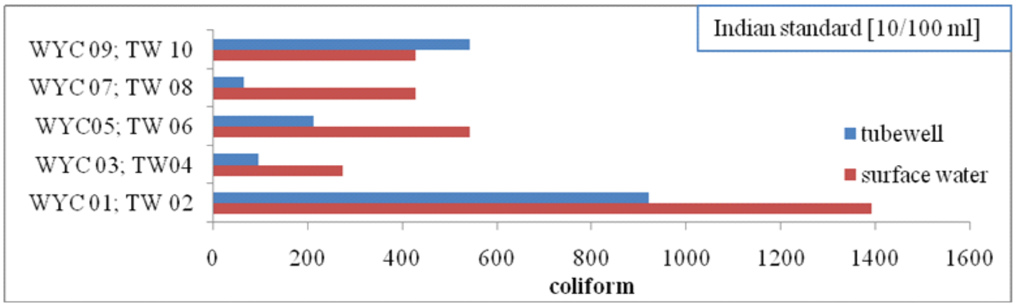

Fig. 11: Graphical representation of Coli-form

The values of Maximum Probable Number (MPN) found in samples of surface water in figure 11 are in the range of 272 to 1392 per 100 ml. As per BIS the permissible limit is 10 per 100 ml. The result values are much higher than the permissible range.The value of MPN found in samples of ground water should be in the range of 63 to 920 per 100 ml. As per BIS the permissible limit is 10 per 100 ml whereas obtained values are much higher than permissible limit.

In the water intended for drinking, E. coli or thermo tolerant coli-form bacteria should be absent or not a single E. coli should be detectable in 95 per cent of samples (100 ml), however BIS considered a permissible limit of 10 per 100 ml. It can be inferred that ground water in this stretch has high coli-form bacteria and is not fit for drinking purpose. Coli-form bacteria are used as an indicator of pollution by human wastes. Most probable number (MPN) represents the bacterial density which is most likely to be present in a water sample(Lenore *et al*., 2005).

CONCLUSIONS

The Western Yamuna Canal is polluted due to industrialization and urbanization in this area. Western Yamuna Canal has become the sewage as well as industrial waste matter is carried through further cities and leads towards River Ganga at Allahabad. Untreated waste from the industries and human settlements are found to be the major cause for deterioration in the water quality in Radaur –Ladwa stretch**.** In this study, various physico-chemical and biological analysis studies revealed that water quality of this stretch belongs to E type, which is suitable only for irrigation purpose but with the high range of pH value the irrigated soil will deteriorate in coming years. The value of parameters is at the boundary line of suitability and unsuitability for irrigation purpose. If water contamination is continued likewise then soil problems as pore clogging and infertility will be identified in future. Thus it is strictly required to develop strict law and minimization techniques to improve the water quality of Western Yamuna Canal for sustainable water use especially for irrigation purpose.

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