ASSESSMENT OF WATER QUALITY OF LBOD SYSTEM AND ENVIRONMENTAL CONCERNS

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ABSTRACT

The system of Left Bank Outfall Drain (LBOD) is one of the major drainage projects ever carried out in Pakistan and World. This system has developed a positive impact on the productivity over large areas of land within its catchment areas, twin problem of salinity and waterlogging in these areas have reduced considerably. However, much of the positive effects in the upper reaches of the drainage catchment have been set off by negative impacts in the tail reaches. Here wetland areas were salinised and a landscape of small lakes interconnected with densely grown wetland vegetation was changed to one large water body with saline and infertile fringes. Drainage System nowadays is facing serious problem of industrial, agricultural, pesticide and municipal effluents by disposal of different pollution sources. The TDS values of collected samples range from 1500 to 23000 mg/L. Similarly the results of other water quality parameters like; calcium, sodium, chloride and magnesium are also higher than the permissible national standards. These contaminants caused degradation of LBOD system and placed serious environmental and health threats. Apart from causing degradation of drainage water quality and the large water bodies' also causing health threat to the local population through waterborne and vector diseases such as malaria have been on a steady rise. It is argued that much of these negative effects could have been avoided by just applying sound engineering principles. This paper presents adverse environmental impacts, such as pollution of the drainage waters, groundwater, and destruction of wetlands.

Keyword: LBOD system, Industrial Effluent, Waterlogging, Salinity, Drainage water

1. INTRODUCTION

The province of Sindh has faced salinity and waterlogging menace since long together with flooding and drainage. This has hampered the efforts for poverty reduction and economic development of the region. The province of Sindh has inadequate drainage capacity to smoothly dispose off rain, escape and drainage water to dispose off such waters away from command areas. Consequently the extended flooding lasts considerably longer and destroys the standing crops and raises the ground water-table rapidly to the surface. Deterioration of surface water quality also takes place when agricultural and industrial toxic wastes substances and effluents are discharged into irrigation canals and drains [1]. The absence clean drinking water is attributed to release of untreated wastewater and dumping of effluent in fresh water bodies [2]. It is estimated that 75 % of the population of developed nations lack clean drinking water and wastewater along with solid wastes are dumped into fresh water bodies [3].

The catchment area served by the mega drainage project of Left Bank Outfall Drain (LBOD) was initiated because of the acute problems of salinity and waterlogging. Hence, the LBOD has been constructed to control twin problem of salinity and waterlogging, and dispose off saline drainage water from an area of 1.275 million acres of Nawabshah, Sanghar and Mirpurkhas components and Badin component area (Culturable Command Area of 0.458 Million Acres). The sub-drains and drains discharge their saline effluent into the Spinal drain right from Nawabshah (Shaheed Benazirabad district) downwards mostly carry agricultural and industrial effluents almost round the year [5]. However, in many parts of district Badin; the system has failed to give the desired results and has caused severe problems of land degradation and submergence of the area by saline water [6].

Drainage is nowadays identified as the forgotten factor in sustaining irrigated agriculture [7]. In the past drainage systems were designed for continuous operation and very little consideration was given to the environmental impact of the drainage water on surface water quality [8] with the resultant loss of water and an excessive load of salt being transported to surface water [9] along with any dissolved agricultural chemicals. The problem with accumulation of salts highlights the environmental concerns associated with drainage from arid irrigated lands [10].

The daily life human activities cause the pollution of fresh water bodies particularly the run-off from agricultural fields in agricultural countries. It is estimated that about 1.5 billion population around the world have no safe clean drinking water and about five million deaths per year are attributed to waterborne diseases [11]. It is estimated that 70 percent effluent from industries are disposed off without treatment into fresh water bodies and that contaminates the receiving water supplies in the developing countries [12].

The main sources of water contamination in the system of LBOD include; discharge of untreated wastewater, dumping of urban solid waste into drainage system, discharge of untreated industrial wastewater into freshwater bodies, seepage of fertilizers and pesticides from agriculture fields and soil, disposal of toxic sugar mills effluents into surface drains of the main drainage system and seawater intrusion into Tidal Link carrying [13]. Such water pollution is injurious to both the human health and biodiversity. Thus, the downstream population particularly in southern Sindh is exposed to adverse health effects due to both biological and chemical contamination of water bodies. The use of fertilizers and pesticides has increased over the years and are also causing the water pollution [14]. In addition to this the water pollution is also caused by the release of hazardous industrial wastes like persistent toxic synthetic organic chemicals, heavy metals, municipal wastewater and municipal solid wastes [15].
The wastewater generated by this way leaches down into the ground and add with ground water aquifers resulting in the contamination of the prevailing groundwater quality by changing its chemical composition [16]. The untreated effluent released from such industrial operations contaminates surface and ground water equally. It also harms the prevailing eco-system of fresh water bodies and affects the bio-diversity [17].

2. RESEARCH STUDY AREA

The LBOD drainage system as shown in Fig. 1 was launched to manage groundwater table levels and enhance the collection and disposal of drainage water from an area of 1.275 million acres on the Left Bank of the river Indus. The drainage effluent of about 1240 cusecs generated from these systems is disposed off through network of sub-drains, branch drains, main drains, spinal drain, out fall drains and Tidal Link into the Arabian Sea. The saline effluent from the LBOD system flows from the Kotri Barrage command area carried through the Spinal Drain, Dhoro Puran Outfall Drain (DPOD), Kadhan Pateji Outfall Drain (KPOD), and the Tidal Link, to the Arabian Sea

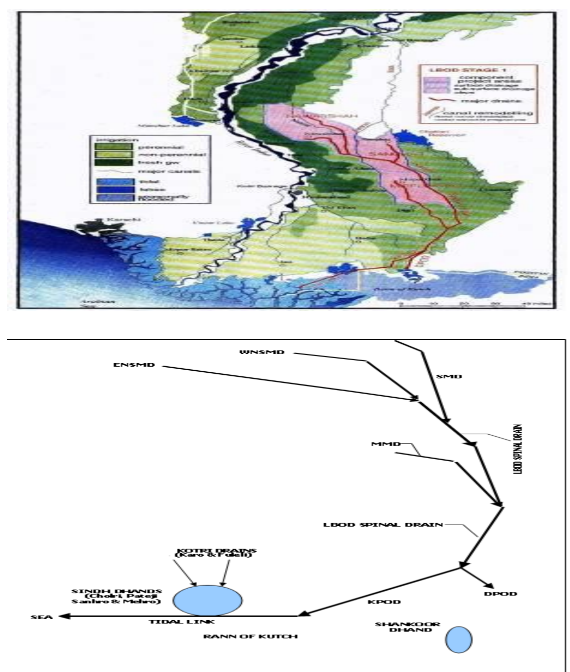

Fig. 1: LBOD project area surface and sub-surface Drainage

3. MATERIAL AND METHODS

The water samples were collected from different sample locations of the main and sub drains of LBOD system. The water samples were collected in clean sterilized plastic bottles and brought to Pakistan

Council of Research in Water Resources (PCRWR) laboratory Tando Jam for analysis. However, pH and Dissolved oxygen (DO) values were observed and recorded at the site. The results of analyzed water samples for physical and chemical characteristics are described below one by one.

4. RESULTS AND DISCUSSION

The pH value ranges from 6.2 to 8.5 according to permissible limits of NEQS. The analyzed results of pH values of 2007 and 2008 are varying from 6.2 to 7.8. Fig. 2 shows that pH values in some drains are close to threshold 7.8 which may degrade drainage water. This water is source of aquatic life and used for irrigating agricultural lands frequently. Moreover, the analyzed results of pH value of 2012 ranging from 6.2 to 7.8. Fig. 3 reveals that the values of eight locations are up to 7.8 while remaining values are lower from 7.8. However, these samples have been collected post floods 2011 from catchment area of LBOD system as shown in Fig.3 in 2012. The pH level should have reduced but concentration of alkalinity is showing increase with respect to time and could not dilute with high flood water 2011. The abrupt variations in pH (acidity and alkalinity) levels can bring stress conditions or eliminate aquatic life. This drainage water is not only room for aquatic life but also source of application water to agricultural crops. Hence, critical value of pH is not only harmful for aquatic life but also cause of degradation of fertile land.

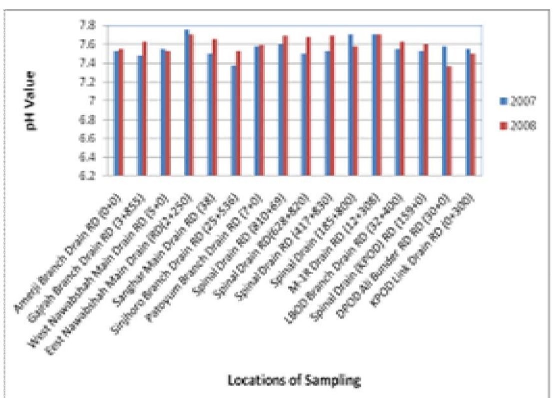

Fig. 2: pH value of years 2007 and 08

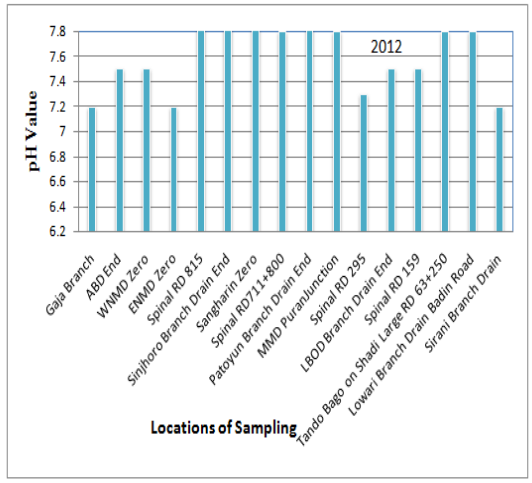

Fig. 3: pH value of year, 2012

The determined TDS values of collected samples range from 1500 to 23000 mg/L and shows a considerable variation of pollution level in the drains of LBOD as shown in Fig.4. The values of TDS of most of the samples are higher than permissible (1000 mg/L) NEQS limit. A high concentration of TDS is an indicator of possibly high value of contamination. Figure4 shows drains water is not only unfit for aquatic, drinking but also for application of agricultural cropping. However, Fig. 5 exhibits that TDS level varies from 500 to 5500 mg/L. this sample was collected after heavy rainfall in watershed area of LBOD system. Hence, TDS levels of drains have been reduced due to dilution of saline water with flood water 2011. If values of TDS in Fig. 4 and Fig. 5 are compared they demonstrate much variation between them.

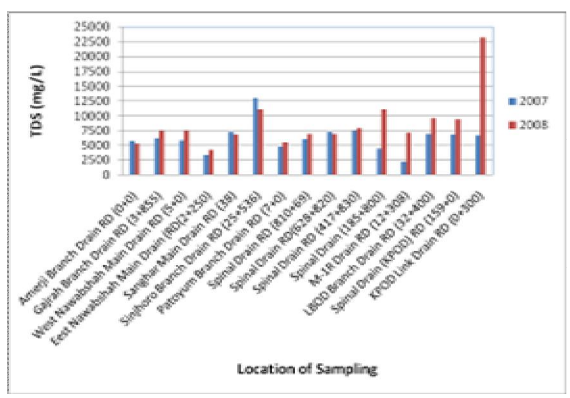

Fig. 4: TDS of years 2007 and 08

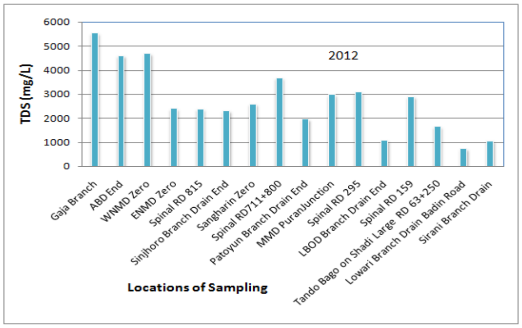

Fig. 5: TDS of year, 2012

The electrical conductivity (EC) of the analyzed water samples range from 2500 to 31000 µS/m as shown in Fig. 6. It is evident from the results that there is no any single drain whose value is within permissible levels as the acceptable level is 680 µS/m NEQS. The Fig. 7 reveals that the value of EC varies from 1000 to 8500. The comparison of values of EC is shown in Fig.6. The value of figure 6 is low due to dilution of drains' water in flood water 2011.

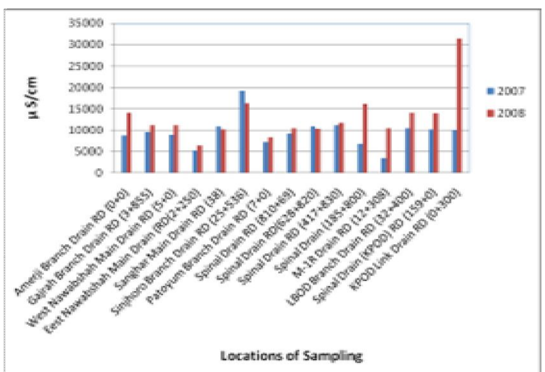

Fig. 6: Electric Conductivity of years 2007

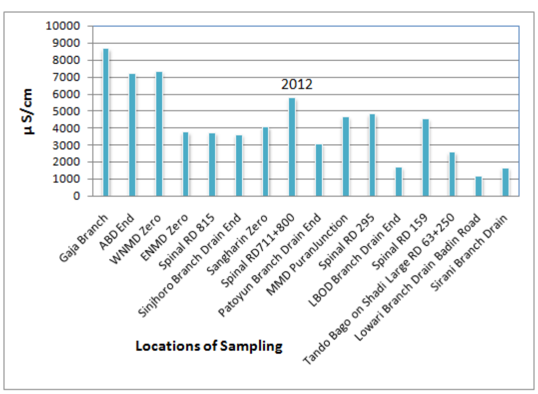

Fig. 7: Electric Conductivity of year, 2012

The collected samples were analyzed for calcium (Ca). The results were found higher than permissible NEQS values. Fig. 8 shows that calcium levels almost all drains are higher due to disposal of waste water from various sources i.e. industrial, municipal and agricultural effluents. The source of increasing calcium is due to sugar mills which are located in catchment area that are disposing off waste directly into drains without any treatment. This level of calcium is very detrimental for aquatic life while irrigating fertile lands. The comparison of Fig. 8 and Fig. 9 which demonstrates that calcium levels in Fig 9 low due to dilution with flood water 2011.

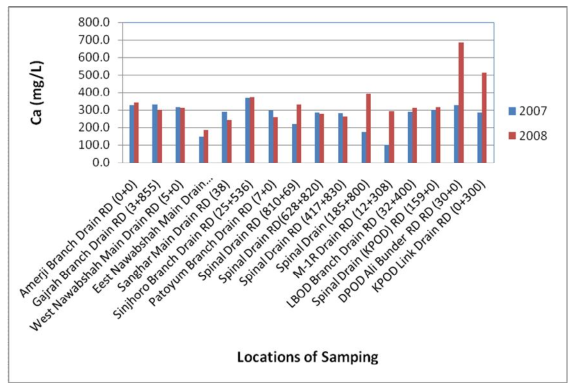

Fig. 8: Calcium of years 2007 and 08

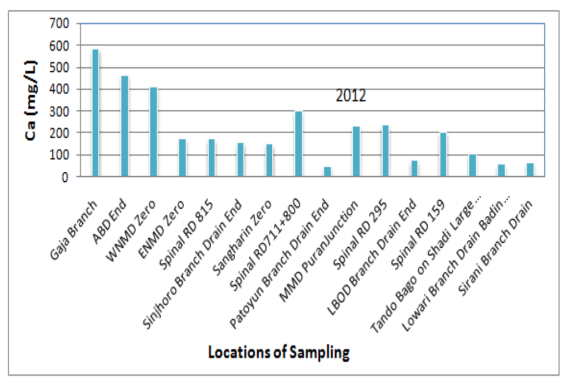

Fig. 9: Calcium of year, 2012

All the samples indicate that there is higher concentration of magnesium (Mg) in the drain water. It is due to the high quantity of ingredients containing magnesium used during the manufacturing process of the industrial units. Comparatively Fig. 10 represents larger concentration than Fig. 11. The Fig. 11 shows less concentration of magnesium due to dilution with flood water 2011.

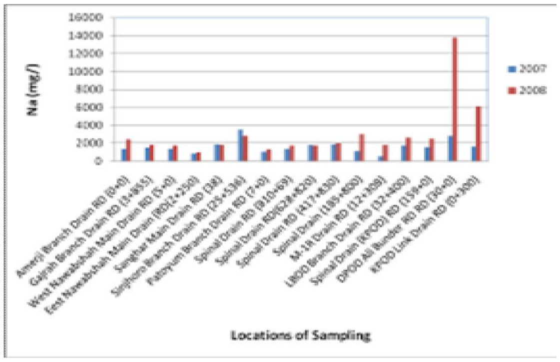

Fig. 10: Magnese of years 2007 and 08

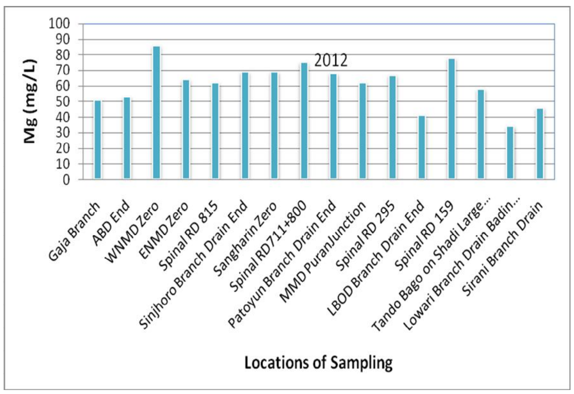

Fig. 11: Magnese of year, 2012

The presence of sodium (Na) in the samples is due to release of wastewater from various sugar mills in the watershed area of LBOD system. Therefore, the Fig. 12 and Fig. 13 indicate that there is larger quantity of sodium. Comparatively it was recorded that Fig. 12 represents larger concentration of sodium than Fig. 13. There is less concentration in figure 13 because the samples were collected post flood 2011.

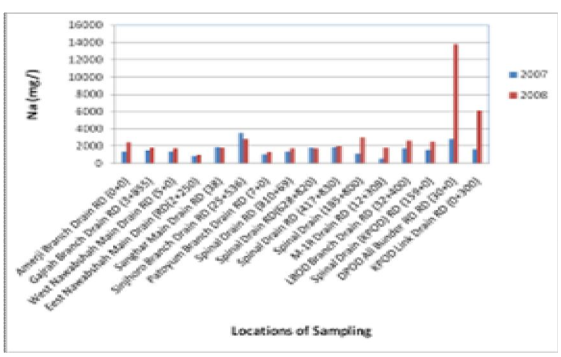

Fig. 12: Sodium of years 2007 and 08

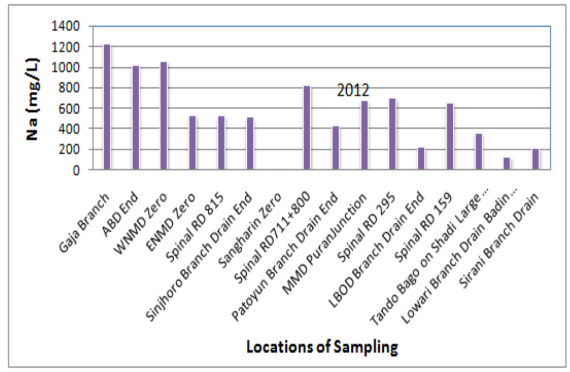

Fig. 13: Sodium of year, 2012

The chloride (Cl_2) concentrations are showing higher values than the permissible levels of NEQS as shown in Fig.14 and Fig. 15. Comparatively it was observed as shown Fig 14 the higher concentration of chloride because of combined effluent generated from units of sugar mills as they use of the higher quantities of the ingredients containing chlorides during the manufacturing process.

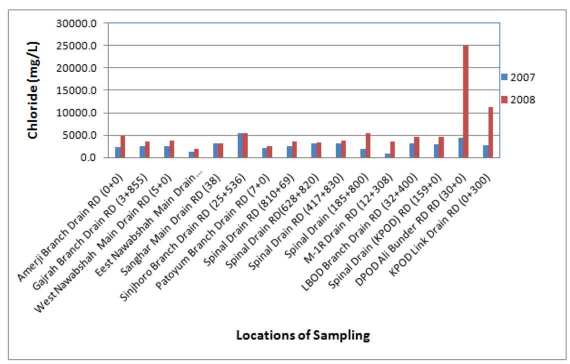

Fig. 14: Chloride of years 2007 and 2008

Fig. 15: Chloride of year, 2012

The hardness of all the samples as shown in Fig.16 and Fig. 17 are not within the limits of NEQS, whereas of hardness of sample obtained from West branch Nawabshah drain is too high than the permissible limits. The higher value was found at all locations as shown in Fig. 16 and its comparison is shown in Fig. 17. The higher level is due to the operational activity of sugar mills units.

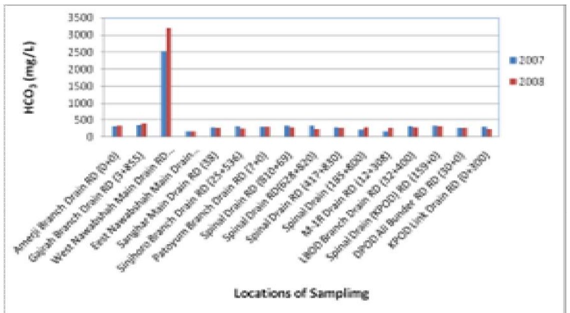

Fig. 16: Bicarbonate of years 2007 and 08

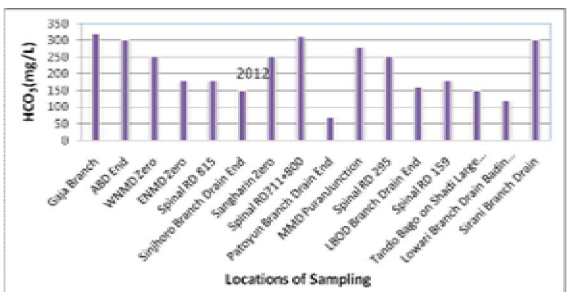

Fig. 17: Bicarbonate of year, 2012

The results of sulphate (SO_4) of analyzed samples as shown in Fig. 18 and Fig. 19 are higher than the permissible NEQS levels. Comparatively it was observed that as in Fig. 18 and Fig. 19 higher concentration of Sulphate because of combined effluent being discharged from different types of industrial units of Sugar mills.

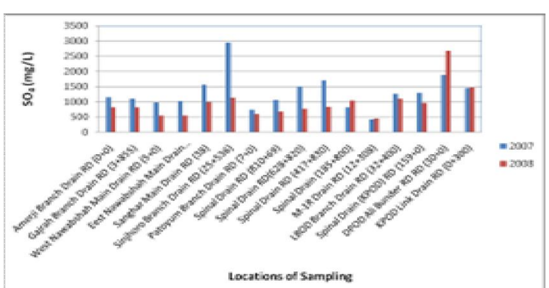

Fig. 18: Sulphate of years 2007 and 2008

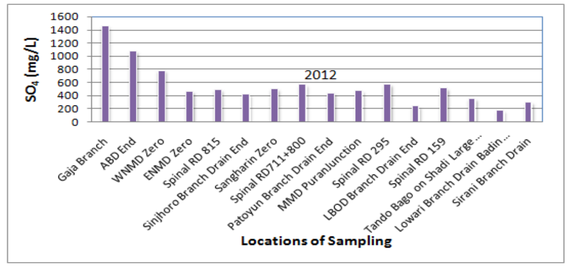

Fig. 19: Sulphate of year, 2012

Sodium in irrigation water can adversely affect the soil beneath the plant canopy. The water quality parameter known as sodium adsorption ratio (SAR) is useful when assessing the likelihood that sodium will be a problem in that regard. Water high in salinity as well as sodium may present additional problems. There are limits of SAR low sodium water SAR 0 to 10, medium sodium water SAR 10 to 18, High sodium water SAR 18 to 26 and very high sodium SAR above 26. Fig. 20 shows results of analyzed samples collected from different drains of LBOD system the values vary from 8 to 55 but frequently to close to 20. However, such water quality of drains is harmful all types of soils and requires good drainage, high leaching, gypsum addition.

Soil minerals such as calcite ($CaCo_3$) has low solubility and contribute to water only small increase in salinity as shown in Fig. 21.

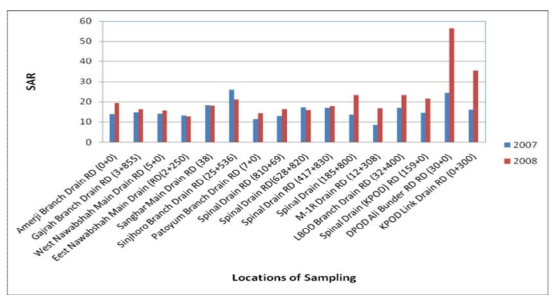

Fig. 20: Sodium Adorpation ratio

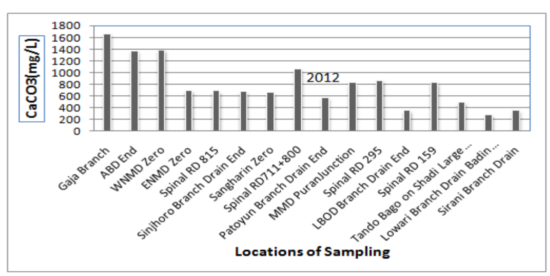

Fig. 21: $CaCO_3$ of year, 2012 of years 2007 and 08

The analyzed values for ortho phosphate (PO_4) indicates that there is high quantity of phosphate available in the wastewater sample, which shows the wastewater generated from factories is also mixing in drain water. Therefore the value of the Ortho phosphate become higher in all collected samples. The maximum value was recorded at Gaja drain and MMD as shown in Fig. 22.

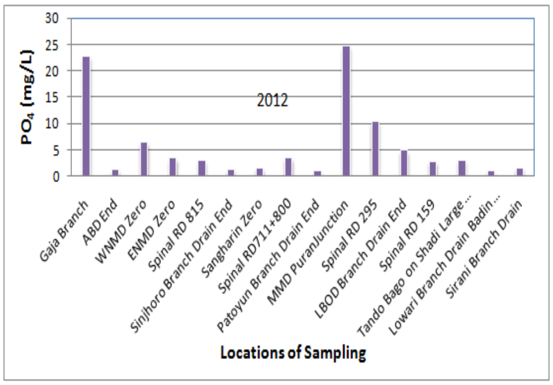

Fig. 22: PO_4 of years 2007 and 08

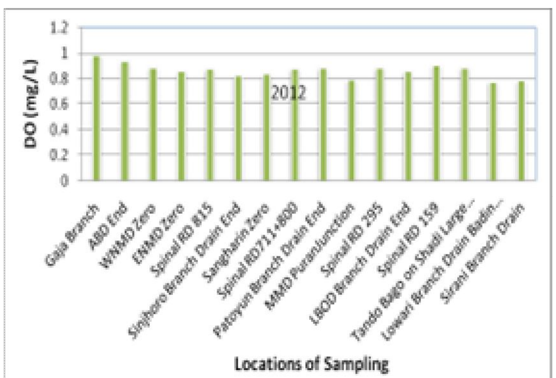

Fig. 23: D.O values of year, 2012

These analyzed results of dissolved oxygen (D.O) also indicate that there is low oxygen for aquatic life in water bodies which may cause death of ecological habitat and aquatic life as shown in Fig. 23. The lower levels of D.O indicate presence of higher quantities of organic related impurities. The organic load consumed D.O for its decomposition. The fish cannot survive at such low D.O level in water bodies if it is less than 2 mg/l as against a permissible threshold of 4.0 mg/l. The reduced D.O levels are detrimental for fish and it is almost impossible for the fish to survive under this environment having low D.O level in the water.

5. ADVERSE ENVIRONMENTAL IMPACT

The soils in the nearby drainage system have been found degraded due to the application of contaminated water of drains for growing crops due to irregular availability of canal water in catchment area of drainage network.

The contaminated drain water effects the livestock Fig. 24, such as buffalos, cows and goats suffer from diseases and die due to consumption of the effluents discharged into drains.

Fig. 24: LBOD in 2010

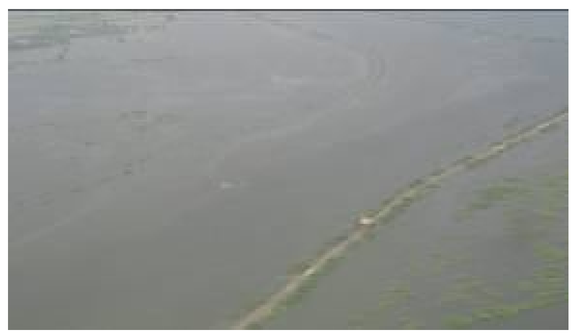

Fig. 25: LBOD during flood 2011

The birds and other aquatic fauna heavily rely on fish present in the drainage system as shown Fig 25. These big water bodies get significant attraction from the local as well migratory birds particularly in the winter season. However such contaminated water may cause threat to this aquatic life and consequently may affect the food chain system.

The agricultural and industrial wastewater in-filtrating through the soil from drains may contaminate the ground water. The human population living in the close vicinity has to depend only on ground water but that ground water may severely contaminate.

6. CONCLUSIONS

The untreated wastewater from industrial units as well as from domestic sources into drains of LBOD system is highly contaminated and contains pH, EC, TDS, sodium, calcium, magnesium, hardness, SAR calcium carbonate and lower limits of DO. Hence, this water is unfit for drinking and its application for irrigation is harmful for the fertility of soil. Additionally that wastewater from industrial units particularly from sugar mills without treatment was found harmful for ecosystem in the catchment area of LBOD system.

The poor water quality of drains is not only degrading fertile soil, surface water but it is also contaminating groundwater. Hence, without treatment of wastewater causes toxic water quality for aquatic life and ecological habitat. The results of collected samples in 2007 and 2008 are of very nature which shows that drain water is not fit for drinking and irrigation. Whereas, the analyzed result of collected samples in 2012 reveals better than 2007 and 2008 because the drain water was diluted with floodwater, during the year 2011 flood.

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