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Legal Framework to Control at Disposal Point Source Urban and Industrial Effluents of Hyderabad City into Pinyari (Old Phulleli) Canal off-taking from Kotri Barrage, Sindh

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Abstract: Pinyari (old Phulleli) canal off-takes from left bank of Kotri barrage is last Hydraulic structure on Indus river. This canal is passing from periphery of Hyderabad city and its design discharge is 13,636 cusecs which supplies fresh water not only for agricultural, industrial purpose and drinking purpose for the several towns and villages because groundwater in its command area is highly saline and not drinkable. The cottage factories and Hyderabad industrial area are located on nearby banks of canal. Hence, effluents from city and industrial SITE area are directly disposed off into the canal. The disposal of untreated wastewater created health and environmental safety problem. This paper presents that the analyzed results of water quality parameter ie pH, TDS, EC, Na, hardness, K, Mg, Mn, DO and BOD of collacted samples exhibit TDS 6%, K 20%, DO 67% and BOD 54%, respectively exceeded permissible limit. While pH, Na, hardness and Mn found within prescribed limits. Total coliform /E.coli (MPN/100ml) were found positive. Furthermore, the result of Water Quality Index (WQI) model reveals that water quality of canal of collected samples varies from excellent to very poor that reveals canal water is unsuitable for drinking purpose and aquatic life and also causes various waterborne diseases. Therefore, the local people are facing serious health problem by consuming water canal. With an attempt to ensure enforcement of environmental water laws in Sindh province of Pakistan for preventing degrading clean water. These environmental water laws have already been framed, but due to lake of enforcement, water pollution problems are increasing day by day. The enforcement of environmental water laws are very essential to control water pollution for safety of human health, and ecology in Sindh, Pakistan.

Keywords: Environmental water laws, water quality assessment, water quality index, canal water, wastewater.

Introduction

Hydrogen and Oxygen (H_2O) constitute water which is available on surface as well as sub-surface of earth, and found in all living organisms. Water is natural source which is essential for living things but it is one of the most poorly managed resources on surface of earth, which are wasted and polluted. Obviously, human beings disregard natural source (Jothivenkatachalam et al., 2010). The survival of mankind and environment have not only depended on freshwater but also its excellent and good quality standard (Vega et al., 1998). The river system is one of the most natural resources of water supply to different countries of the globe. At river source, the water is relatively clean as it flows towards downstream. Rivers are under threats from ill planned development (Rahman and Owais, 2014). The main reason for this is that all main known and unknown points of contamination (domestic, agricultural and industrial) are concentrated along with system and function together to reduce water quality standard which impacts are harmful to public health and environment (Venkatramanan, et al., 2014).

Water pollution is addition of any organic or inorganic substances which may alter the properties of water and render it unfit for a particular use and adversely affects living existence (Tassaduqe, et al., 2003). In Pakistan, water pollution is mainly from disposal of sewerage, industrial and agricultural runoff into fresh water bodies which cause many acute waterborne diseases. According to reported cases of 40 percent deaths in Pakistan are water related diseases like typhoid, diarrhea, cholera infective hepatitis etc. About 25 percent of overall deaths of children below 5 year age are, particularly due to gastroenteritis and diarrhea diseases (Mahessar, et al., 2020). In Pakistan, about 45 percent deaths of infants are due to diarrhea and 60 percent due to overall infectious waterborne diseases. About 25 to 30 percent waterborne diseases are gastrointestinal in nature as per the World Health Organization (PCRWR, 2015). The population of Baluchistan, KPK and Sindh of 72 %, 46 % and 24%, respectively depend on unsafe water sources. Pakistan rankings at 79 in the world in water quality standards by using poor water quality for drinking (PCRWR, 2005). The noticeable contaminating activities are disposal of domestic, industrial, and agricultural runoff into freshwater bodies (intentional or accidental). According to the WHO guidelines/ Sindh Environmental Quality Standards (SEQS) the water quality must be suitable for human consumption (Mahessar, et al., 2017). In order to sustain safe water quality of freshwater resources, there is a need of practically maintaining and sustaining water quality as per Environmental Quality Standards (Mahessar, et al., 2016). It is environmental water law binding to the industrial sector for installation of in-house treatment plant and its safe disposal to prevent environment from

contamination (Mahessar, et al., 2016, Mahessar, et al., 2015).

The environmental water laws already exist such as Sindh Environmental Protection Act, 2014, Sindh Irrigation Act, 1879 and Sindh Water Management Ordinance, 2002, and Pakistan Environmental Protection Act, 1997. Hence, there is a challenge to enforce these laws practically for protection of freshwater resources from further degradation. The industrial sector does not follow the standards and guidelines of federal and provincial environmental laws for inhouse treatment of effluents their monitoring, and reporting under SEPA Act, 2014 and PEPA Act, 1997. Under federal legislation article 20, relevant to drinking water of the amended Factories Act of 1934 and provisions of the PEPA Act, 1997 relate to prevention of water contamination and disposal of effluents (PEPA, 1997). The PPC (1869) provides criminal penalty against polluting the water of any public reservoir or spring. The Sindh Irrigation Act 1879 and the Canal and Drainage Act (1873) prohibits the fouling of canal water. Sindh Fisheries Ordinance (1980) prevents the discharge of industrial waste and untreated sewage into water, and held the responsible to the enforcement of punishment for offence (Azra Jabeen et al. 2015).

Materials and Methods

Study Area

Hyderabad is second populated city of Sindh province of Pakistan after metropolitan Karachi which is located at latitude 25°.41822 and longitude 68°.39539 on left side of Indus river with about 2.0 million population. The city has non-functioning wastewater treatment plants, thus the effluents of city and industrial SITE area is disposed off into Pinyari canal. The GIS map shows locations of collected canal water samples from nearby known disposal points of wastewater into canal which is passing through periphery of Hyderabad city (Fig. 1).

Geographical Position System (GPS) used for geographical co-ordinates and Software of Geographical Information System (GIS) for developing GIS map. Canal water (CW) samples have been collected from different locations (Fig. 1). Nitric acid (HNO_3) was added in sufficient quantities to reduce the pH level of the samples for about 2, for stabilizing total concentration and dissolving metals in about 20 days maximum. The collected samples were preserved in an icebox and sent to laboratory of PCRWR, Karachi for further analysis.

Model Karl Pearson Correlation Matrix was used for Statistical analysis. Karl Pearson linear correlation matrix (Mahessar, et al., 2019) was used for analyzing parameters of physicochemical to make relationship among different physicochemical parameters for analysis matrix correlation (Table 1).

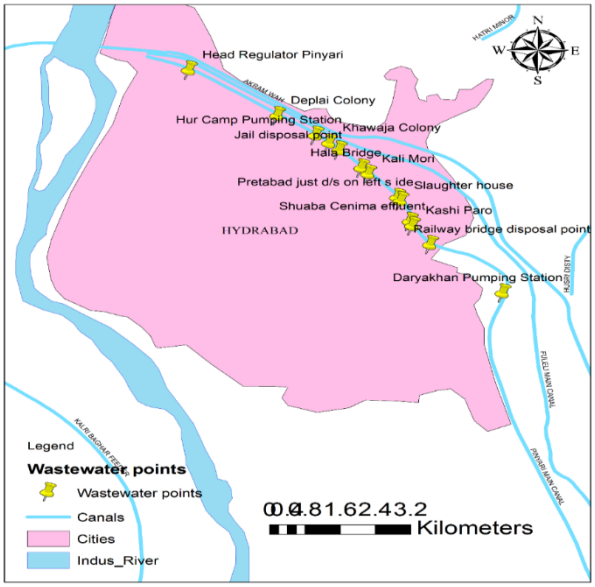

Fig.1 Locations of samples of canal water and wastewater disposal point.

Water Quality Index (WQI) model is indicator for measuring suitability of drinking water quality and shows results of different parameters of water samples for knowing standard of water quality (Farid et al., 2012) . The WQI equation is described as under:

$$QWI = \sum_{n-1}^{n} Wi * Qi \quad (1)$$

Whereas,
Wi is weight associated with ith WQ parameter
Qi is sub-index for ith WQ parameter,
n is number of WQ parameters

Table 1. Water quality index.

WQI Rating					
S. No.	**QWI Value**	**Rating Water Quality**	**S. No.**	**QWI Value**	**Rating Water Quality**
1	0 - 25	Excellent	4	75 - 100	Very poor
2	25 - 50	Good	5	>100	Unsuitable for drinking purpose
3	50 -75	Poor			

Furthermore, review was made of following environmental water laws facing challenges of enforcement in Sindh province of Pakistan through relevant organizations and departments.

- Pakistan Environmental Protection Agency (PEPA 1997)
- Sindh Environmental Protection Agency, (SEPA-2014)
- Sindh Water Management Ordinance (SWMO), 2002
- Sindh Irrigation Act,1879
- Factories Act (1934)

Results and Discussion

During sample survey the major disposal points were identified from city area including pumping station at Deplai colony, Pumping station at Jacob Station Jacob, besides, direct wastewater from Mubark colony, Kari Mori barrage, Railway Line Bridge and further wastewater from Industrial SITE area at Darya Khan pumping station (Fig. 1). Further, the survey was conducted at Hyderabad SITE area which is located on Hill and its adjacent area, Hyderabad. There are 360 industrial units as per collected data from Sindh Environmental Protection Agency. There are different types of industries established at the SITE area such as textile, leather, Ghee corporation, cement factory, Dal mills, Cotton mills, glass industries, agriculture manufactures, fruit industries, spicing grindings, pharmaceutical , iron and steel, cotton waste, tiles and lime. These industries produce huge amount of wastewater which is disposed off into canal without any treatment through sewage drain network.

pH

The pH is basic (alkaline) nature of a solution and a measure of the acidic. The result of analyzed samples shows that the values of pH vary from 6.5 to 8.5 which is within prescribed limit of National Environmental Quality Standard (NEQS). The pH values of canal water between 6.5 and 8.5 range is suitable for drinking and aquatic life.

Total Dissolved Solids (TDS)

The analyzed result of canal water samples reveals that values of TDS of all samples are within permissible limit as per NEQS but except sample 13. The values of samples CW-1 and 2 are lowest because these samples were collected before disposal of wastewater into canal while value of sample No. 13 is due to disposal of effluent from SITE area into canal. The values of TDS vary from 237 to 2029 mg/L.

Hardness

The analyzed result of hardness of canal water samples presents that the values of all samples are within the permissible limit of NEQS. The values of all samples vary between 55 to 225 mg/L range and maximum value was obtained at location of canal water sample CW-13, which was taken from canal nearby disposal point of SITE area.

Sodium (Na)

The result of analyzed samples exhibits that the values of all canal water are within prescribed limit as per NEQS except sample CW-13. The value of sample CW-1 is lowest which was collected at disposal site of head regulator of canal against other collected samples. The sample values vary from range 20 to 195 mg/L. The Na content of sample CW-13 is highest in comparison of remaining samples because this sample was taken from canal nearby disposal point of indusial wastewater. In SITE area, there are various categories of established industrial units such as textile, soap, paper and other units, which require larger quantities of sodium for the manufacturing purpose.

Potassium (K)

The analyzed result of K of canal water samples shows that the values of all samples are within permissible limit as per (12 mg/L NEQS) except samples 4, 8 and 13. The value of sample CW-1 is lowest against all samples because this sample has been collected from point of head regulator, which is not close to disposal wastewater point. The values of samples vary in range from 3 to 42.8 mg/L. Lack of Potassium will be potential cause of fatal condition known as hypokalemic, typically resulting from vomiting and diarrhea, and its deficiency also causes respiratory problem and muscle weakness.

Magnesium (Mg)

The value of sample CW-1 was lowest against other samples because this sample was taken from at disposal site of head regulator of canal. The values of samples vary from 7 to 142.6 mg/L. Magnesium is essential metal for nutrient and its excess or deficiency will cause for negative health effects.

Manganese (Mn)

The values of samples No. 1 and 2 are lowest in comparison of other samples because these samples were taken before disposal of wastewater into canal. However, the values of all canal water samples were found within prescribed limit. Iron and manganese in combination with natural or man-made organic compounds will cause even stunting problems.

Dissolve Oxygen (DO)

The analyzed results of canal water samples show that the DO values of sample No.1, 2, 3 and 6, 7 are within permissible limit, and in remaining samples were found below permissible limit. While values of samples No. 12 and 13 were found lowest because these samples were taken at nearby disposal point of industrial effluent into canal. However, the values of samples vary in range from 0.5 to 6.75 mg/L. The analyzed results of many samples showed lower level of DO than recommended value

of 4 mg/l. The lower DO level than 4 mg/L may cause the death of aquatic life.

BOD

The result of analyzed canal water samples shows that the values of samples No. from 1 to 5, 10 and 14 are within permissible limit while the values of samples No. 6, 7, 8, 9, 11, 12, 13 and 15 are found above prescribed limit. The values of samples vary in range from 1.7 to 260 mg/L. There was lowest value of BOD in samples which were collected before disposal points of wastewater. Hence, major impact of wastewater was observed on canal water. This variation in canal water chemistry is due to frequent disposals effluents into canal. The changes in BOD may cause loss of aquatic life.

The analyzed results of Water Quality parameter ie pH, TDS, EC, Na, hardness, K, Mg, Mn, DO and BOD of collected samples exhibit that TDS 6%, K 20%, DO 67% and BOD 54%, respectively exceeded permissible limits. While pH, Na, hardness, Mg and Mn were found within prescribed limit. The results further indicate that disposal of wastewater of various categories of effluents such as industrial, household, cottages, slaughter houses, and agricultural and animals wastes into canal which contaminate water of canal and ground water, and environment. Therefore, ISO-14000 standard must be adopted to prevent environment from contamination. The degradation of canal water can be prevented through installation of modern type treatment plant at disposal point sources, using GIS tools for monitoring at wastewater locations, and by further enforcement of Environmental Water laws.

Pearson Linear Correlation Model

Karl Pearson linear correlation matrix (Mahessar et al., 2019) used physicochemical parameters to analyze the relationship among various physicochemical parameters for computation matrix correlation (Table 2) such as pH, Electric conductivity and Total dissolved solids, hardness, DO, BOD, Na, K and Mg The correlation of EC with TDS, is very strong. The pH has weak positive relation with EC, TDS.

Table 2. Pearson correlation matrix of physiochemical parameters

Parameters	pH	EC	TDS	HCO3	Hardness	DO	BOD	Na	K	Mg
pH	1									
EC	0.234	1								
TDS	0.234	1	1							
HCO3	0.351	0.919	0.919	1						
Hardness	0.141	0.891	0.891	0.831	1					
DO	-0.255	0.382	0.382	0.378	0.526	1				
BOD	0.125	-0.007	-0.007	0.183	-0.092	-0.07	1			
Nitrite	0.129	-0.229	-0.229	-0.18	0.011	0.355	-0.199			
Na	-0.012	0.111	0.111	0.156	0.512	0.176	-0.003	1		
K	0.51	0.806	0.806	0.787	0.591	0.146	0.126	-0.128	1	
Mg	0.015	0.547	0.547	0.555	0.738	0.535	-0.099	0.579	0.365	1

Analysis of Water Quality Index (WQI)

The result of Water Quality Index (WQI) reveals that water quality varies from excellent to very poor. Samples No 1 and 2 rating is excellent because first (1) sample was collected at D/s head regulator and second sample in front of Deploi disposal point, sample No. 3 good, sample No.4 poor and samples from 5 to 14 were found very poor respectively (Table 3). Hence, canal water quality is unsuitable for drinking purpose.

Table 3. Water quality index rating

S. #	Latitude	Longitude	WQI	S. #	Latitude	Longitude	WQI
1	25°.45339	68°.38372	10.799	8	25°.41456	68°.42522	160.802
2	25°.44706	68°.39622	10.358	9	25°.424	68°.42389	113.551
3	25°.41994	68°.39989	39.743	10	25°.41517	68°.42078	100.758
4	25°.43556	68°.38939	74.196	11	25°.39433	68°.42267	105.574
5	25°.44178	68°.39383	140.847	12	25°.39472	68°.42256	256.660
6	25°.4225	68°.39322	107.665	13	25°.41517	68°.42078	549.148
7	25°.42822	68°.39839	127.675	14	25°.43261	68°.39033	287.442

Microbiological Analysis

The microbiological analysis of collected samples from canal water nearby disposal points of wastewater of urban and industrial area shows that Total Coliform/Ecoli MPN/100 ml are positive, except in sample No.1. The presence of fecal coliforms causes various waterborne diseases. A drinking water sample is considered safe for human consumption which does not have any coliform per 100 ml.

Health Assessement

The prevalence of various diseases such as, hepatitis, diarrhea, gastroenteritis, kidney, blood pressure and heart problem, cancer, bones pain and skin diseases are common among the locals residing in major and small cities, towns, villages, households located in command area of canal. The patients of waterborne diseases almost died without any treatment due to financial crisis which leads them towards highl risk. Therefore there is need of practical enforcement of Environmental Water Laws to prevent degrading freshwater of canal network for ensuring safety of humans and ecology.

Legal Aspects

Pakistan's Environmental Water Laws and their Compliance Regulatory Provisions should effectively be enforced by relevant agencies, organization departments to prevent water pollution and timely

action should be taken against polluters. The Canal and Drainage Act, 1873 Sindh Irrigation Act, 1879, and The Punjab Minor Canal act-1905 are the legal Acts for preventing water pollution in the Indus basin. Futher, Sindh Fisheries Ordinance 1980, The factories Act 1934 prevents discharge of untreated wastewater from industries in water sources. The factories Act 1934 Rules, clause 14 on disposal of waste effluents mentions effective arrangement should be made by factory for process of manufacturing and fines for polluters.

Provisions Related to Pollution Control

The basic provisions relating to pollution control are contained in sections 11, 13, 14 and 15 of the Pakistan Environmental Protection Act 1997. Section 11 prevents release of any waste in excess of the National Environmental Quality Standards (NEQS) and Section 13 prohibits from importing hazardous effluents. Under section 17 PEPA Act whoever fails to comply with provisions of this Act is punishable with fine of one million (PEPA, 1997). Under Section 11 of Sindh Environmental Protection Act,2014; no person shall discharge or allow the discharge of any effluent, waste, pollutant or other matter that may cause or likely to cause pollution or adverse environmental effects. The Sindh Water Management Ordinance, 2002; CHAPTER – X, Offences and Penalties.

Legislation

Legal provisions and regulations should be enforced by the concerned agencies, departments and organizations for preventing and controlling water pollution through using all sources, technologies and also deploy the competent staff for monitoring of disposal of wastewater sources and coordinate with relevant stakeholders.

Prohibition

Restrictions must be enforced to avert freshwater bodies from pollution as their water is used for drinking purpose.

(a) Disposing of municipal, industrial, commercial and agricultural wastewater in fresh water bodies.

(b) Encroachment over canal banks, water animals and washing of clothes in canals judicious use of fertilizer and chemical pests as agricultural inputs which pollute freshwater bodies by run-off from agricultural fields.

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