Impact of the Effluents of Hyderabad City, Tando Muhammad Khan, and Matli on Phuleli Canal Water

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Abstract—**The demand and supply of safe water is a basic need. The consumption of clean water intensified with population growth and economic development which in turn cause degradation of available freshwater resources while creating huge volumes of wastewater, solid waste, and serious environmental problems. This paper presents the impact of disposing of domestic/industrial effluents into an irrigation canal. The subsequent contamination of the canal water becomes a public health risk. The non-perennial Phuleli canal with a discharge of 15,026 cusecs, takes in water from the left bank of Kotri Barrage, which is the last controlling hydraulic structure on the Indus River. This canal runs from the periphery of Hyderabad, Tando Muhammad Khan (TM Khan) and Matli cities and supplies water for domestic, agricultural, and industrial activities. The canal water is the only source of drinking water for millions of people because the groundwater in the command area of the canal is highly saline. The banks on both sides of the canal have encroached in cities' areas. The huge volume of solid waste and municipal and industrial wastewater from these cities and from the occupied canal banks are dumped directly into the canal without any treatment. The collected samples' were analyzed for pH, EC, TDS, Cl, SO4, HCO3, hardness, Na, K, Ca, and Mg. These results show higher than permissible limits as per NEQS and WHO. The Karl Pearson matrix correlation of parameters reveals strong relation among EC with TDS and CL with SO4, Mg with K and moderated relationship among the other parameters except for pH and DO. Water Quality Index (WQI) model indicates that the water quality of the canal is poor and unfit for drinking. Hence the consumption of canal water is a high potential health risk for locals.**

Keywords-Phuleli canal; Water Quality Index; statistical analysis; efflunets, Hyderabad city; solidwaste; encroachment; degradaion

I. Introduction

Clean water is a precious commodity, but unfortunately degradation of fresh water and air are common throughout the world [1]. Safe drinking water is a basic need and demand [2-4]. Whatever are the environment conditions, people have the right to access safe drinking water in quantity and quality equal to basic needs [5, 6]. In Pakistan, freshwater contamination, due to poor monitoring and management of drinking water quality, is a major threat to the public which is deteriorating mainly as a result of disposal of the municipal and industrial wastewaters into canals [7]. The lack of safe drinking water is attributed to the discharge of untreated wastewater and dumping of effluents in freshwater bodies. The polluted water is used for drinking and industrial and domestic purposes [8]. Since there is no proper safe disposal of wastewater, untreated municipal and industrial wastewater is being discharged directly into canals [9]. The disposal of municipal and industrial wastewater into canals is one of the major causes of environmental degradation, particularly in developing countries [10]. Wastewaters are dumped into fresh water sources. Due to growing population, water bodies like canals, rivers, streams, reservoirs, and oceans are getting polluted [11]. Urbanization is polluting rivers, canals and endangers aquatic life in Pakistan due to solid waste and effluents [12]. In order to keep the quality of irrigation and drinking water, proper environment management per standards is important. It is a legal binding of the industrial sector to manage safe waste disposal and prevent environment degradation [13].

Population growth and industrialization have caused the generation of millions of tons of solid waste and wastewater. The untreated domestic and industry waste have created many adverse problems for public health and the environment [14]. Globally, water quality analysis is carried out on a regular basis by chemists and biologists. It has been found that the increasing population is the main cause of the deterioration of surface and sub-surface water [15]. Major human activities have polluted fresh water sources [16]. In the future, global population growth is likely to occur mainly in the urban areas [17]. Unplanned urban population growth poses pressure on water resources and water contamination has emerged as one of

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the main environmental problems. Population growth brings major impacts on water management supply, wastewater management, sewerage safe disposal, surface drainage and can cause public health problems [18]. Industries clustered in urban and semi-urban areas surrounded by densely populated localities, continue to pollute the environment with impunity [19]. Some water polluted effects are identified immediately whereas others are not revealed for months or years [20]. There is an increasing concern on the human health impacts attributed to water pollution. About a quarter of the diseases human population faces today are caused by prolonged water contamination, while most of water pollution relative diseases are not easy to detect [21]. The majority of wide communicable diseases are waterborne [22, 23]. Environmental pollution is a worldwide problem [24]. There is no doubt that excessive levels of pollution are causing damage to public health and the environment.

II. STUDY AREA

A. Geography and Population

Phuleli Canal starts from the left bank of Kotri Barrage. It passes through the periphery of Hyderabad city and provides water to Hyderabad, TM Khan, and Badin districts. This canal is non-perennial. Water is released for domestic purposes in the dry season. The total length of the canal is 721.8 miles, which covers a GCA of 1,003,100 acres and CCA of 920,847 acres with full supply discharge of 15,026 cusecs (Figure 1).

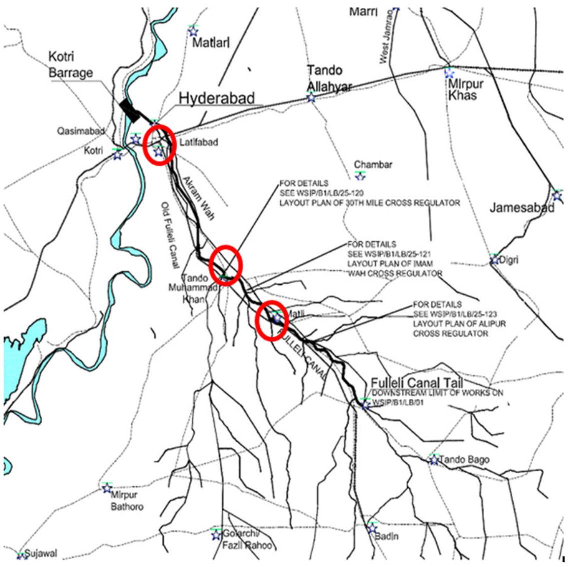

Fig. 1. Research study area

Since Phuleli Canal flows through the ridge of Hyderabad city along with Pinyari Canal on its right and Akram Wah (Lined Channel) on its left, many inhabitants have constructed their homes on its embankments as shown in Figure 2. It is also a source of direct disposal for untreated domestic and industrial wastewater and solid waste. Water consumption has increased, and with its increase, the volume of wastewater has also increased. This practice is creating serious environmental problems to the people of Hyderabad city while those living in the downstream areas including TM Khan, Matli, and Badin districts are also facing serious health and environmental problems. The objective of the current research is to determine the impact of wastewater disposal of Hyderabad city, TM Khan, and Matli towns on public health and aquatic life. The people have completely or partially encroached the canal banks in its passing from these cities/towns. Untreated water is being discharged into the canal from different locations of Hyderabad city, TM Khan, and Matli as shown in Figure 2.

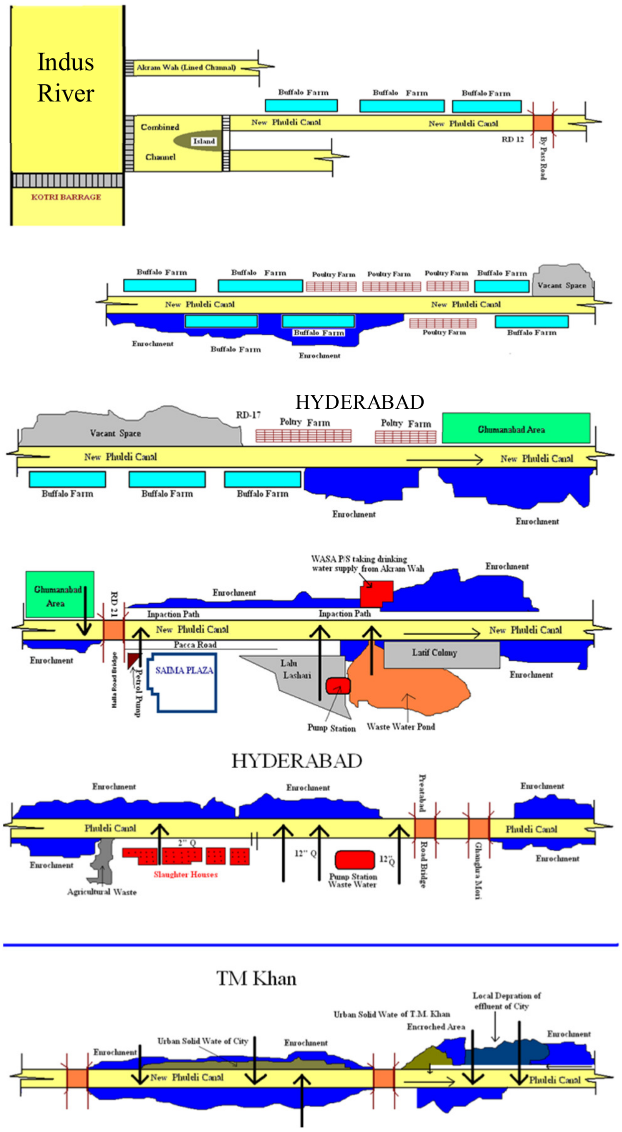

Fig. 2. Schematic plan showing various locations along the banks of Phuleli Canal where wastewater and solid waste are dumped besides THE points of human settlements between RD-4 to RD-35 and TM Khan town

B. Hydrology and Climate

The temperature varies with seasons, the hottest months are May and June and the coldest are December and January. Light rains occur occasionally in January and February. The average annual rainfall in the study area varies from 6 to 9 inches. Most of it occurs during the July to September monsoon season. Although the annual rainfall is low, yet the study area is subject to severe storms due to its closeness with the Arabian Sea. Sea intrusion on surface and underground is increasing and has degraded and converted shallow fresh groundwater in saline water.

III. MATERIALS AND METHODS

A. Solid Waste and Wastewater Disposal and Encroachment Along the Canal

A walk through investigation was conducted on the bank sides of the canal in the area of Hyderabad, TM Khan and Matli for assessing and identifying the locations of solid waste dumping and wastewater disposal into the canal and also for collecting wastewater samples as shown in Figure 2.

B. Sample Collection and Analysis

The samples have been collected from locations where wastewater disposal takes place. The physical parameters, i.e. pH, EC and TDS were analyzed in situ. Nitric acid (HNO_3) was inserted in sampling bottles in sufficient quantity to reduce the pH level of the samples to just about 2, in order to stabilize the concentration of total and dissolved metals for a maximum of 28 days. Standard sample transfer procedures were adopted including labeling, and safe transportation to the laboratory of Pakistan Council Research for Water Resource at DRC Tando Jam. The names and locations of sample collection are shown in Table I.

TABLE I. SAMPLES' COLLECTION NUMBER AND LOCATION

Locations of collected Samples			
Sample no.	**Location**	**Latitude**	**Longitude**
S1	Saima Plaza	25°24'48.82"	68°24'48.80"
S2	Lalo Lashari	25°24'39.82"	68°23'27.82"
S3	Slaughter house	25°24'22.73"	68°23'30.30
S4	Pretabad	25°24'29.54"	68°23'21.54"
S5	Hosri	25°18'59.21"	68°24'57.71"
S6	TM Khan	25°7'36.29"	68°32'15.05"
S7	Matli Bridge	25°2'15.70	68°36 36.88"

IV. RESULTS AND DISCUSSION

A. Effluents in the Canal from Solid Waste and Wastewater

There are many locations of effluent disposal on the sides of the Phuleli canal in Hyderabad. Untreated wastewater from small industries and municipal areas is being discharged into the canal. There are about 13 disposal locations on the left side and 14 on the right side of the canal where an estimated amount of 1.0 million gal/day untreated wastewater is disposed into the canal. The estimated quantity of solid waste which is being accumulated on the embankments of the canal is about 20-25 tons per day. Numerous buffalo farms (BFs) were found nearby The waste of all BFs is directly dumped into the canal because all farms have been established on the canal banks as shown in Figure 2. The effluents of TM Khan are directly disposed to the canal. Also, clothes are washed in the canal and the same water is used for domestic purposes because the groundwater is saline. Matli town has only the canal as a source of drinking water because groundwater is saline and is not fit for drinking. The encroachment is not only a source of canal water pollution, but also develops obstacles and reduces the canal capacity. Hence, the encroachment not only degrades canal water but also damages the canal system. Rain flood season is an indicator of emergency due to the possibility of occurrence of a breach in canal network. The wastewater samples of Hyderabad, TM Khan, and Matli were collected and analyzed. The analyzed results are described below.

1) pH

The pH measures the alkalinity or acidity of the water. Fresh water is always slightly alkaline due to the presence of carbonates. The pH values of all the water samples from Hyderabad city, TM Khan, and Matli towns are exhibited in Figure 3. We can see that the pH values of the collected samples are between the lower (6.5) and upper limit (8.5) according to NEQS.

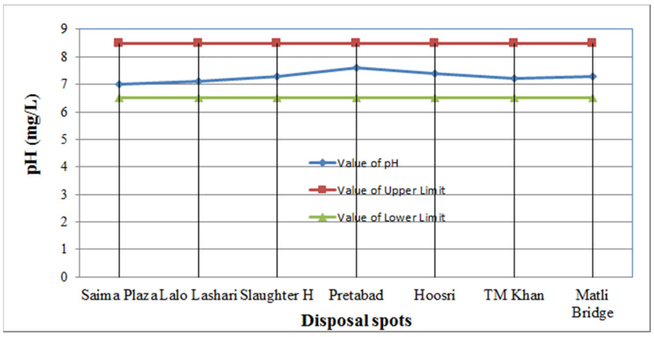

Fig. 3. Samples' pH values

2) Electrical Conductivity (EC)

The EC of the analyzed samples ranges from 1000 to 2700μS/m as shown in Figure 4. The maximum value of EC is at Slaughter house and the lowest at Saima Plaza, while the values of all locations are higher than the permissible level which is 680μS/m.

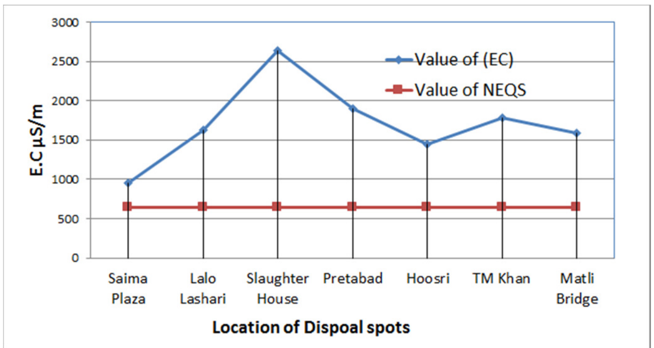

Fig. 4. Electric conductivity values

3) Total Dissolved Solids (TDS)

TDS is a measure of inorganic solids and of the amount of organic substances present in the water. The results of the collected samples show that TDS values vary from 600 to 2600mg/L with most areas being above the permissible limit of NEQS as shown in Figure 5.

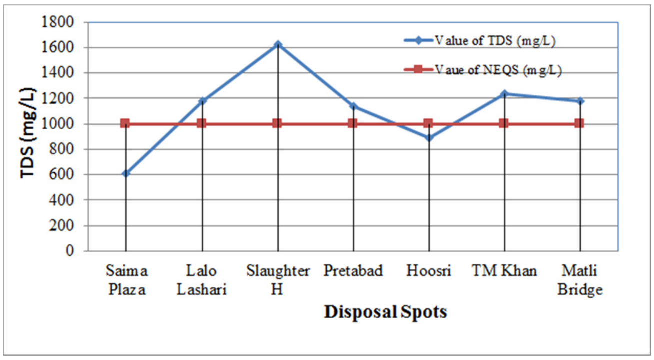

Fig. 5. TDS values

4) *Chloride Content (CC)*

Wastewater samples' CC values are shown in Figure 6. It can be seen that most locations have values higher than the permissible limit of 250mg/L. The lowest CC is measured at Saima Plaza. Increase of CC beyond the safety limit does not pose any significant health problem but rests with the test.

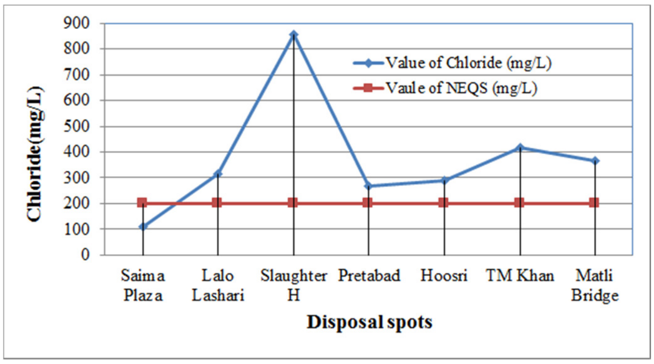

Fig. 6. CC values

5) *Dissolved Oxygen (DO)*

The recommended value of DO in normal drinking water is 8mg/L. DO is an indicative of oxygen depletion. Samples collected from Hyderabad city, TM Khan and Matli are lower than the permissible NEQS limit as shown in Figure 7. This result indicates that there is very low oxygen content in the canal water which may threat the ecological habitat and the aquatic life.

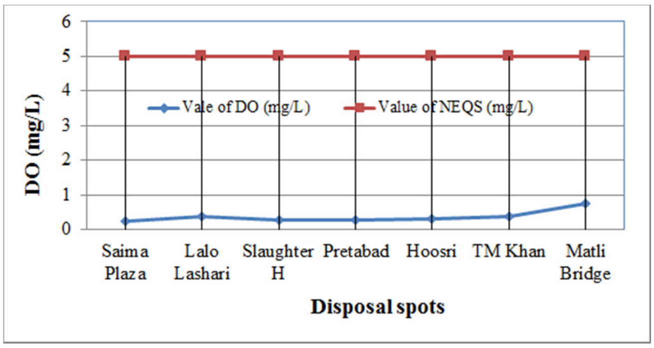

Fig. 7. DO values

6) *Sulfate Content (SO_4)*

The sulfate content of Slaughter house is higher than the permissible limit of 250mg/L as shown in Figure 8. The measured sulfate concentration varied from 75 to 350mg/L. An increase in sulfate level from the recommended value may cause symptoms like diarrhea.

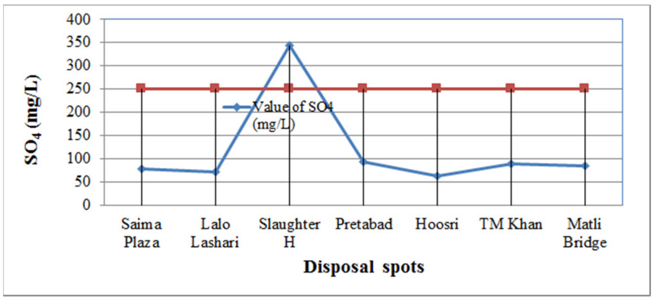

Fig. 8. SO_4 values

7) *Bi-Carbonate (HCO_3)*

The water sample of Slaughter house shows a higher level in comparison with the other samples. All bicarbonate values are higher than the permissible limit of 120mg/L as shown in Figure 9.

8) *Total Hardness (TH)*

According to WHO, the hardness should not exceed 500mg/l. The analysis of the results of the collected samples shows that the values of the samples lie within this level, although they are higher than the NEQs limit (Figure 10). TH beyond the WHO permissible limit was found only at the Slaughter house.

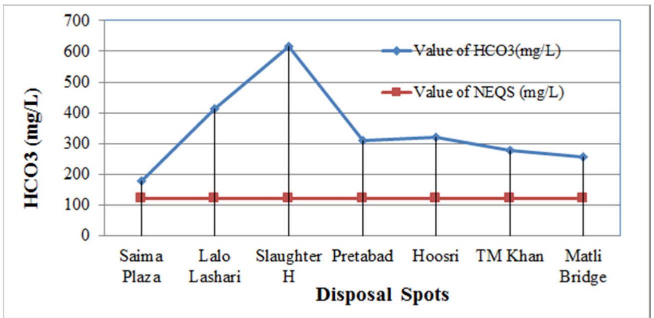

Fig. 9. HCO_3 values

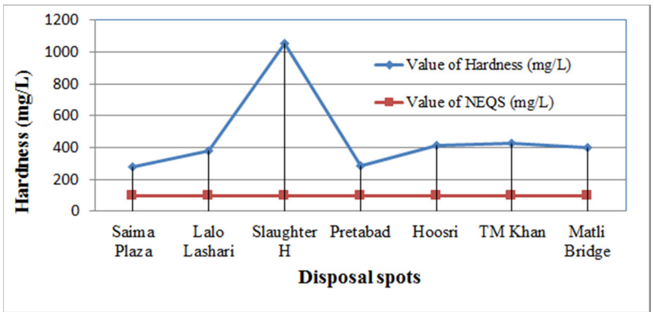

Fig. 10. TH values

9) Sodium (Na)

Various industrial units which require larger quantities of Na (textile, soap, paper, etc.) have been established in Hyderabad city. Therefore, Figure 11 indicates that the larger quantity of sodium (600mg/L) was found in the Slaughter house in Hyderabad city area, while the permissible limit of NEQS is 200mg/L.

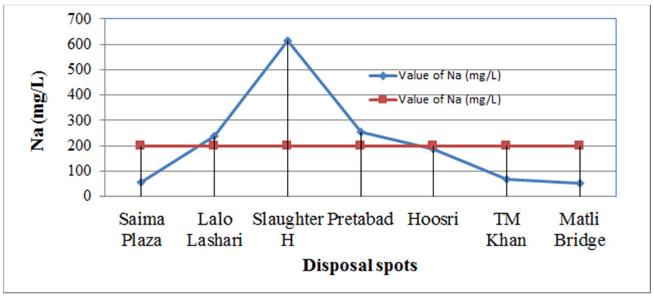

Fig. 11. Sodium values

10) Potassium (K)

Due to the usage of larger quantity of potassium in the Slaughter house area, the graph shows that the larger quantity of K was found at that location as shown in Figure 12. The values of the other collected samples are within the NEQS permissible limits.

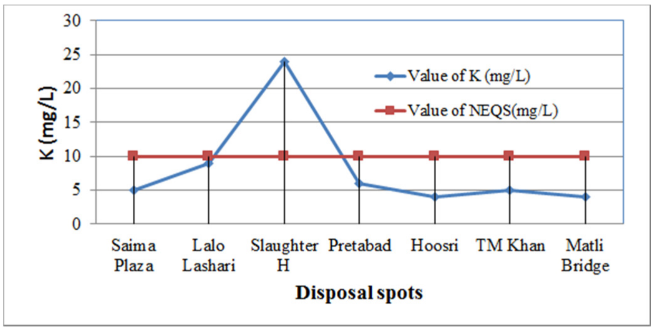

Fig. 12. Potassium values

11) Calcium (Ca)

Calcium is a soft grey alkaline earth metal that is used as a reducing agent in the extraction of thorium, zirconium and uranium. Ca is essential in muscle contraction activation, helps in building bones and teeth, blood clotting, nerve impulse transmission, heart-beat regulation, and fluid balance within cells. Figure 13 shows that it ranges from 50 to 230mg/L. The maximum value of Ca was found at the Slaughter house. The value at Lalo Lashari and Pretabad was 125mg/L, while the other values were less than the NEQS permissible limit.

12) Magnesium (Mg)

Mg is a nutritionally essential metal that can be responsible for adverse health effects when in deficiency or excess. Its water content increases with hardness. The value of Mg is maximum at the Slaughter house (and way above the permissible limit), whereas the values of the other collected samples are lower than the permissible limit (Figure 14).

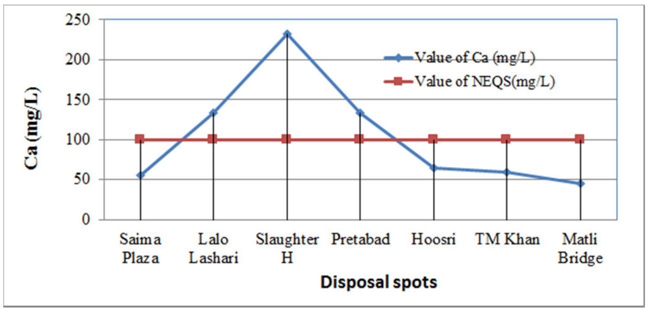

Fig. 13. Calcium values

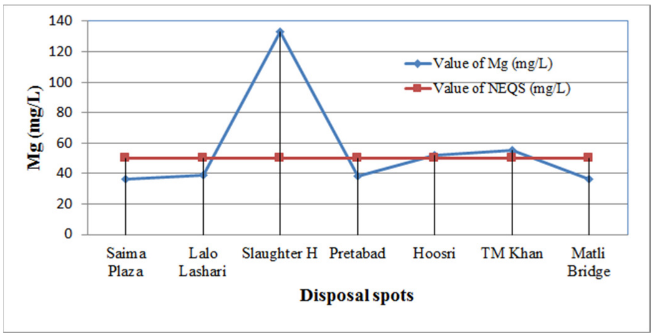

Fig. 14. Magnesium values

The analyzed results exhibit that contamination with TDS, EC, SO_4, Cl, Na and TH in the canal water poses high potential risk to the locals, especially those who use as drinking water at the downstream of the canal.

B. Water Quality Index (WQI)

WQI model summarizes the analyzed parameter results of the collected samples regarding water quality [25-26]. The equation of the WQI model is:

$$QWI = \sum_{i=1}^{n} Wi * Qi \qquad (1)$$

where Qi is the i^{th} WQ parameter, Wi is a weight associated with the i^{th} WQ parameter, and n is the total number of WQ parameters. WQI is an indicator of water quality/suitability for drinking purposes.

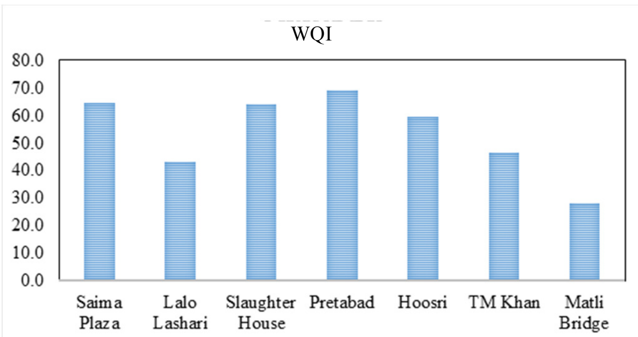

Fig. 15. WQI of Phuleli canal

Figure 15 shows the WQI values for each sampled location. Saim Plaza, Slaughter house, Pretabad and TM Khan have been found to be in poor state regarding WQI, while only Lalo Lashari and Matli are within normal range.

C. Karl Peason Correlation Matrix

The Karl Person linear correlation matrix [27] of considered physicochemical parameters has been used to analyze the relationships among various physicochemical parameters for computation matrix correlation as described in Table II. Karl Pearson correlation matrix of parameters reveals strong relation of EC with TDS and CL with SO_4, CC with Mg, Ca with Na, and hardness with K and moderate relationships among the other parameters except of pH and DO. The strong correlation among these parameters shows that the canal is polluted from frequently disposing of wastewater from the study area.

D. Health Assessement

Health assessment has been conducted regarding waterborne diseases through a distributed questionnaire in the study area. It was assessed that the polluted canal water was used for drinking which is could cause various water borne diseases like dysentery, cholera, hepatitis and migraine among the locals who are living in the downstream areas of the canal.

TABLE II. PEARSON CORRELATION OF PARAMETERS

Parameters	pH	EC	TDS	CC	SO_4	HCO_3	TH	Na	K	Ca	Mg	DO
pH	1											
EC	0.436	1										
TDS	0.301	0.954	1									
CC	0.166	0.923	0.905	1								
SO_4	0.091	0.829	0.733	0.916	1							
HCO_3	0.174	0.875	0.825	0.884	0.841	1						
TH	0.061	0.833	0.773	0.965	0.963	0.886	1					
Na	0.281	0.845	0.712	0.819	0.884	0.950	0.863	1				
K	0.003	0.816	0.737	0.886	0.964	0.923	0.939	0.937	1			
Ca	0.219	0.831	0.721	0.758	0.838	0.922	0.780	0.968	0.922	1		
Mg	0.087	0.820	0.720	0.935	0.964	0.861	0.984	0.873	0.933	0.787	1	
DO	0.021	-0.074	0.156	-0.013	-0.237	-0.222	-0.149	-0.395	-0.305	-0.408	-0.300	1

V. CONCLUSIONS

The encroached areas on the canal banks are the main cause of canal water pollution and must be dealt with. Protecting or retaining of walls along the canal from RD-4 to RD-40 at Hyderabad city, from RD 1148 to RD-155 at Tando Muhammad Khan town, and from RD-200 to RD-210 at Matli town on both sides must become a priority. The wall height should be 5ft for the prevention of encroachment, solid waste dumping, and wastewater disposal. The results of the collected samples for parameters such as pH, EC, TDS, CC, SO_4, HCO_3, hardness, Na, K, Ca, and Mg exhibit values higher than the permissible limits. The Karl Pearson correlation matrix of parameters reveals strong relation among EC with TDS, CC with SO_4, Mg with K, and moderate relationship among the other parameters except pH and DO. Water Quality Index indicates that the water quality of the canal is poor and unsafe for drinking. Hence, consumption of canal water is a potential health risk. Among the collected samples from different locations of Phuleli canal, the sample collected from the Slaughter house location posed the highest values in comparison with the other locations, but all locations were above the permissible limits of at least some parameters. The results of this study show that the water quality is poor, making the water unfit for drinking.

Water is released into the canal only during the dry season period because the canal is non-perennial. Treatment plants have been installed at SITE, Latifabad, Qasimabad and at the ISRA University. These treatment plants should be updated for recycling and new plants should be constructed in TM Khan and Matli. Water quality monitoring program should be carried out on a regular basis. RO filtration plants should be installed at suitable places for providing safe water to the residents in the command area of Phuleli canal. Basic health facilities should be provided to the locals for water-borne disease treatment. An awareness program could be carried out. Sindh Environmental Protection Agency (SEPA) should play a proactive role and regularly monitor the pollution levels with coordination with the stakeholders. District governments of Hyderabad, TM Khan, and Badin should establish a steering committee with coordination of stakeholders to regularly observe canal water quality and take appropriate measures to address the problem.

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