American Journal of Biomedical Sciences
ISSN: 1937-9080
nwpii.com/ajbms

Pollution and Encroachment of Phuleli Canal along the Periphery of Hyderabad City of Pakistan

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Received: 26 January 2014; | Revised: 22 April 2014; | Accepted: 7 May 2014

Abstract

Rivers and canals are major source of irrigation and drinking water that have been badly polluted with industrial waste and sewage water. Fecally contaminated canal water is a major source of diarrheal diseases in Pakistan. Phuleli canal in Hyderabad is a main water supply source for both irrigation as well as human consumption. However, it is greatly polluted with industrial and domestic waste. This study reports the encroachments as well as sewage and solid waste disposal points along the periphery of the Phuleli River in Hyderabad city of Sindh. We report a high number of waste disposal points, and encroachments along the canal bank polluting the water. Water analysis by using standard tests also reveal high level of heavy metals and pollutants than the WHO recommended limits. We conclude that the situation may be largely improved by controlling the encroachments and disposal of solid waste and sewage into the canal.

Keywords: Phuleli Canal, encroachment, pollution, heavy metals, solid waste etc.

1. Introduction

Water quality of many rivers in Pakistan is being spoiled due to the inflow of industrial domestic waste water [1]. In Pakistan, surface water (such as canals, rivers, lakes) is the major source of drinking water. Urbanization is greatly polluting the rivers and canals and endangering aquatic life in Pakistan due to solid waste and effluent. Population encroachment and the pollution of rivers and canals with sewage water are not only spoiling the aquatic life [2] and damaging agricultural land, but also of public health concern. The same water is used for drinking purpose at some point and used for dish

washing, laundry and recreational purposes [3, 4]. Faecally-contaminated water is a major source of diarrheal diseases in Pakistan [3, 5-7].

Kotri barrage is the last controlling structure constructed on the Indus River, built on the confluence of Hyderabad, Kotri and Jamshoro cities, in 1955. The barrage was constructed to pass a maximum flow of 24,780 cumecs (875,000 cusecs). It is a source of domestic, industrial and irrigation water supply for an area of about 1.126 million hectares (2.78 million acres) and more than 25 million people. There are four canals off-taking from Kotri Barrage, one from right bank and the rest from the left bank [8].

Phuleli Canal off-takes from the left bank of Kotri Barrage. It runs through the periphery of Hyderabad city and provides water for agricultural, industrial and domestic purposes to Hyderabad, Tando Muhammad Khan and Badin districts. This canal is non-perennial, but the water is released for domestic purpose in dry seasons. The total length of the canal is 721.8 miles, which covers GCA of 100, 3100 acres and CCA of 920847 acres with full supply discharge of 15026 cusecs.

Due to increase in population and waste disposal into the canal, local inhabitants of Puleli region experience level of increased level of water borne illnesses. Since Phuleli Canal passes through the ridge of Hyderabad city (second largest city in Sindh province) alongwith Pinyari Canal on its right, while Akram Wah (also called as Lined Channel) on its left, many inhabitants have constructed their homes on its embankments. Besides, it is also a site for direct disposal of untreated domestic and industrial wastewater and solid waste. Encroachment and industrial pollution of canal water has direct impact on the human health as well as Agriculture. The consumption of water has increased, and with its increase, the volume of wastewater has increased. This practice is creating serious engineering and environmental problems to the people of Hyderabad city while those living in the downstream areas including Tando Mohammad Khan and Badin districts are also facing serious health and environmental problems [8, 9]. Since the reports of public health problems such as gastrointestinal diseases are not uncommon in this part of the country, our department attempted to study the extent of encroachment on canal water and carried out the analysis of canal water.

2. Methods

The study was conducted during the period August 2010 and October 2010. Temperature ranged between 28-45°C (day time). All encroachment points were identified by visiting the sites and on the basis of available record from Irrigation department of the Government of Sindh.

Water and effluent samples were collected from different locations to assess the quality of water in Phuleli Canal and brought to the laboratory for the analysis. WHO standard values for drinking water were used for the comparison of the canal water. The locations of collected samples and their laboratory results have been recorded. Three water samples were taken and the results are average of three readings.

3. Results

The wastewater of encroachment and city area is discharged into Phuleli canal through pumping and gravitational flow. The field survey was carried out to identify the disposal locations and quantify their usual discharge (Fig. 1). There are a total of 13 locations on the left side and twenty four locations on right side of the Phuleli Canal where wastewater generated from small industries (cottage, plastic & dyeing of Ajrak) and municipal areas is being discharged directly into the canal. The wastewater flow was measured at each location and total estimated discharge of untreated wastewater being disposed-off in to the canal is about 1.0 million gallons/day. Releasing of untreated wastewater into fresh water canal is hazardous for human life as well as for flora and fauna. Its impact is badly felt by the downstream users of Tando Mauhammad Khan and Badin districts. Since these areas are not served with conventional water treatment facilities, therefore, people of these localities (who are mostly poor) are more prone to water-borne diseases.

In following are the details of many waste water disposal points and encroachments areas (Table 1):

Table 1: Details of encroachment populations and waste disposal near Phuleli Canal

S. No	Encroached Population	Location (RD)	Disposal Item	No. of Pipes	Diameter (Inches)
1	Pathan Goth	7 to 9 R/S	Waste Water Pipe	2	6
2	Pathan Goth	7 to 9 R/S	Waste Water Pipe	1	4
3	Pathan Goth	7 to 9 L/S	Waste Water Pipe	1	4
4	Pathan Goth	RD 11 R/S	Waste Water Pipe	2	4
5	Pathan Goth	RD 11 R/S	Open Nala	4	N/A
6	Pathan Goth	RD 12 R/S	Waste Water Pipe	2	6
7	Pathan Goth	RD 13 R/S	Open Nala	2	N/A
8	Pathan Goth	RD 14 R/S	Waste Water Pipe	4	6
9	Pathan Goth	RD 15 R/S	Waste Water Pipe	2	4
10	Pathan Goth	RD 15 R/S	Open Nala	3	N/A
11	Pathan Goth	RD 16 R/S	Waste Water Pipe	2	4
12	Pathan Goth	RD 17 R/S	Open Nala	4	N/A
13	Pathan Goth	RD 18 R/S	Waste Water Pipe	2	4
14	Pathan Goth	RD 19 R/S	Waste Water Pipe	2	6
15	Pathan Goth	RD 20 R/S	Waste Water Pipe	3	4
16	Pathan Goth	RD 11 L/S	Waste Water Pipe	1	4
17	Pathan Goth	RD 12 L/S	Waste Water Pipe	1	12
18	Pathan Goth	RD 12 L/S	Waste Water Pipe	6	4
19	Saima Plaza	RD 21 R/S	Waste Water Pipe	1	12
20	Abid Petrol Pump	RD 21 R/S	Waste Water Pipe	1	6
21	Abid Petrol Pump	RD 22 R/S	Waste Water Pipe	6	6
22	Abid Petrol Pump	RD 22 R/S	Open Nala	3	N/A
23	Laloo Lashari	RD 23 R/S	M.H.C	1	12
24	Laloo Lashari	RD 24 R/S	Waste Water Pipe	4	6
25	Laloo Lashari	RD 24 R/S	Waste Water Pipe	3	4
26	Laloo Lashari	RD 25 R/S	Waste Water Pipe	6	6
27	Laloo Lashari	RD 25 R/S	Waste Water Pipe	4	4
28	Laloo Lashari	RD 26 R/S	H.M.C	1	12
29	Laloo Lashari	RD 27 R/S	Waste Water Pipe	2	6
30	Laloo Lashari	RD 28 R/S	Waste Water Pipe	1	4
31	Laloo Lashari	RD 29 R/S	H.M.C Nala	1	42
32	Khuresheed Town	RD 21 L/S	Waste Water Pipe	4	6
33	Khuresheed Town	RD 22 L/S	Waste Water Pipe	1	12
34	Kohli Goth	RD 32 R/S	Waste Water Pipe	1	6
35	Kohli Goth	RD 33 R/S	Waste Water Pipe	1	6
36	Kohli Goth	RD 33 L/S	Open Nala	1	N/A
37	Ghangra Town	RD 36 L/S	Waste Water Pipe	3	6
38	Huseri Town	RD 63 L/S	Waste Water Pipe	1	18
39	Seri Town	RD 99 L/S	Waste Water Pipe	1	18

Abbreviation: RD = , L/S= left side, R/S = right side, RD = Reduced distance

Figure 1. The Head Regulator of the Phuleli Canal

Figure 2. Buffaloes bathing in the canal water at RD-32

3.1 Buffalo farms at downstream of bypass bridge

About 15 farms of buffaloes have been constructed on the left flank of canal at downstream of bypass bridge (Fig. 2). During our visit, it was observed that wastewater and solid waste of farms and houses is being disposed of into the canal. An average of 60 buffaloes were maintained in each farm for supplying milk to Hyderabad city. A large portion of manure and urine of buffaloes and other type filth is being dumped into the canal. These pollutants from the farms are degrading the fresh water of canal and become source of many diseases.

3.2 Poultry farms

Besides, eight poultry farms were found from RD-10 to 15 RD on the right side of canal at downstream of Bypass bridge. The wastewater, solid waste and dead chickens are dumped into the canal.

3.3 Pathan village

Pathan village is located between RD-8 and RD-9. The wastewater of village is being released through two pipes of 6" and 4" diameter on the right side of the canal. There are about 90 houses in this village and its population is about 2000. The effluent of this village is discharged into the canal. On the left side parallel of the Pathan village, there are about fifteen houses and buffalo farms. The effluents and solid waste from houses and farms are being directly disposed off into the canal.

3.4 Huge encroached area from RD-16 to RD-20 on the right side of canal

During the field visit, it was found from RD-16 to RD-20 on right side of the canal about more than two thousand houses have been constructed on the bank of canal and inside the canal area. This is a dense encroachment as no space has been left even for walking along the canal. The encroached area from RD-16 to RD-20 is vulnerable to floods during high flows at full supply level of Phuleli Canal. It is estimated that about 10 cusecs wastewater is discharged into canal and estimated 3 tons of garbage, manure, and urine of cattle is disposed-off into the canal every day

3.5 Ghumanabad at RD-20 on left flank of canal

Gumanabad is located at RD-20 on left side of canal where encroachment has been done inside the canal area. This is a highly populated area wherein about 5, 000 people are residing. The wastewater, garbage, manures and urine of cattle of this area is directly being disposed-off into canal. The wastewater of Ghumanabad and encroached locality area is about 8 cusecs, which varies during a day. About 4 tone garbage is dumped into the canal.

3.6 Khurshed Town at RD-21 on left side

Khurshed Town is located on the left side of canal at RD-21 downstream of Hala Naka road bridge. There are two wastewater pipes of 6 and 12 diameter, through which wastewater outfalls into the canal. About 6 cusecs of wastewater is being discharged into canal from these pipes. The solid waste and other type of filth is dumped into the canal. The solid waste of Hyderabad city is also dumped at the same point. The dumped garbage is not only degrading the canal water but also deteriorating environmental health in adjacent area since it is creating various types diseases.

3.7 Wastewater of Saima Plaza at RD-21

During field visit, it was observed that the wastewater and solid waste of Saima plaza and nearby area is being disposed off into canal. Saima plaza is located on right bank of canal at RD-21. The wastewater of Saima Plaza is being discharged into canal through a pipe of 12 diameter and it is estimated discharge is about 5 cusecs while 1 ton solid waste, foul of plaza and adjacent area is disposed-off into canal.

3.8 Petrol pump at RD -21

This pumping station is situated on the right side of the canal at RD-21. The waste water and oil waste is being discharged into canal. The wastewater and solid waste of pumping station is causing irreversible damage to the canal. During visit, one pipe of 6" diameter was found, being used for disposal off wastewater.

3.9 Pumping station and open structure at RD - 23 on the right side of canal

Laloo Lashari village is located on the right side of the canal at RD-23. During visit, open structures at RD-23 and RD-26 were found through which wastewater is being discharged into the canal and solid waste of this area is being dumped into canal (Fig. 3). The pumping station with 12" diameter at RD-22 has been constructed by WASA-HDA for pumping wastewater during full supply level of canal. The four wastewater pipes diameter 6 inches at RD-24, three pipes of diameter 4 at RD-24, 6 pipes of diameter "6" at RD-25, two pipes diameter 6 at RD-27 and one pipe of diameter 4 at RD-28 on the right side of the canal were found. The wastewater of this area is released through pipes and open structure into the canal. The estimated discharge from this area is about 12 cusecs, which is released into the canal and about 3 tones of highly polluted garbage is being dumped into canal.

Figure 3. Solid waste and garbage being dumped into the Phuleli canal

3.10 Slaughter houses at RD-27 on right side of canal

The main slaughter house of Hyderabad city is located on right bank of Phuleli canal at RD-30 in the area of Pretabad and Laloo Lashari village wherein about more than 100 animals are being slaughter every day. The huge quantum of pathogen and carcass of slaughterhouse is directly dumped along with the blood of animals of slaughter into the canal. The carcass of slaughtered animals is estimated about hundreds of tons per day and wastewater from this area is about 5 cusecs into the canal. This solid waste is not only source of polluting of the fresh water of the canal but spread bad odor in the adjacent area. The carcass of animals is heavy which is dumped inside the canal; therefore, accumulated solid waste is not being washed away in the canal. Since this canal is non-perennial which flows full supply level during kharif season meanwhile in the Rabi season it only supply water for drinking

and domestic purpose because it flow very low velocity. However, this wastewater and solid waste of slaughtered animals cause of slow poison in the canal' water and source of disturbance of the people which live in the adjacent of slaughter' houses. Other slaughter' houses are located in the city area which dump carcass of slaughtered animals into sewage network of city which ultimately disposes-off into Pinyari or Phuleli canal.

3.11 Pumping station at RD-30 on right side of canal

The wastewater of Pretabad and Mirzabad area is discharged into the canal through pumping station which has been constructed by Hyderabad developing authority (HDA) without considering that canal water is being used for drinking purpose by the local people at downstream of this canal. About 10 cusecs of wastewater is being discharged into canal every day. It may be added that it is not only wastewater that is being disposed off into the river but also 30 tons of garbage and other types of highly polluted solid waste of different sites of city are being dumped into the canal. The dumped material is not only a source of various diseases but also chocking the canal.

3.12 Soil waste dumping at Railway Bridge at RD-31

The collected garbage and other polluted solid waste of industrial and municipal is being thrown on upstream and downstream of Railway Bridge. This garbage is highly polluted which is dumped irrespective of knowing its impact on canal water which is used for drinking by the local people as well as animals. The dumped garbage has chocked the bed width of canal and degraded the fresh canal water.

3.13 Kolhi goth

This village is located on the right bank of the canal at RD-33. Its wastewater is being disposed off through two pipes of 6 inch diameter directly on the right side of the canal. The solid waste and other filth are also directly dumped into the canal. The disposal of wastewater and solid waste is causing pollution of canal waters.

3.14 Encroached area at downstream of Mirpurkhas bridge from RD-34 on right side of canal

In the downstream of bridge, encroachment has been done by construction of houses and buffaloes' farms. The wastewater and solid waste is directly being disposed off into canal. Three are number of buffaloes' farms which are maintaining averagely 30 numbers of buffaloes in each farm. The wastewater, manure and urine and other foul and filth from these farms are being dumped into the canal.

4. Discussion and mitigating measures

Hyderabad is the second largest city of Sindh province having a number of factories, fuel stations, cattle farms, slaughter houses, poultry farms and residential areas greatly polluting the Phuleli Canal water. Population encroachment is not only polluting canal water but also narrowing the river passage. Phuleli river water is used for a number of purposes including bathing, dishwashing, laundry along-with its agricultural utility. Furthermore, aquatic life is also endangered by the toxic compound contaminating the river water. Long term effects of such uncontrolled encroachment and waste disposal into the canal water would be devastating unless appropriate measures are taken.

The direct disposal of domestic and industrial wastewater and solid waste besides encroachment along the banks of Phuleli Canal has created several problems. There are various locations, where untreated wastewater is disposed directly into the Phuleli Canal while at some locations solid waste is dumped into Phuleli Canal by the inhabitants settled at banks, factories, slaughter houses, etc. This practice is polluting the Phuleli Canal at an alarming rate. The settlement of people along the banks is a very serious issue, since it badly hampers the regulation and management of Phuleli Canal and creates enormous problems for the Irrigation Engineers and Staff. Although Sindh Irrigation Act – 1879 and government law do not allow people to encroach the premises of canal command, however, people have settled down

over the period of time. At some locations this has resulted in the narrowing down of water-way. This results in afflux/heading of water in the upstream reach while desired water does not reach at the lower each. This creates in the shortage of water to the people and farmers of Tando Muhammad Khan and Badin districts. The effects of direct disposal of untreated wastewater and solid waste are badly felt by the lower riparian of Phuleli Canal in Tando Muhammad Khan and Badin districts. The locations where untreated wastewater and solid waste are disposed off into Phuleli Canal and settled/constructed houses along the banks are shown in the table 1.

Table 2: Analysis of canal water sample collected from Ghangra Mori at RD-34

S. No.	Parameters	Location of Mirpurkhas Bridge RD 32
1	pH	6.9
2	Color	Greenish
3	Odour	objectionable
4	D. O. mg/L	1.2
5	As mg/L	0.0
6	Microbiological contamination	+ve
7	Temperature ^0C	29.5
8	Conductivity µS/cm	940
9	Salinity g/L	0.5
10	TDS mg/L	602
11	Alkalinity	3.7
12	COD mg/L	740
13	BOD mg/L	260
14	Cl mg/L	143
15	CO_3 mg/L	Nil
16	HCO_3 mg/L	185
17	SO_4 mg/L	65
18	$N0_3$ –N mg/L	3.2
19	Na mg/L	88
20	Ca mg/L	52
21	Mg mg/L	29
22	K mg/L	7
23	Hardness mg/L	250
24	Cu mg/L	0.35
25	Fe mg/L	0.79
26	Cd mg/L	0.023
27	Cr mg/L	BDL
28	Pb mg/L	0.132
29	Ni mg/L	0.342

Table 3: Laboratory results of the wastewater samples collected from various disposal locations

S. No	Parameters	WW-1	WW-2	WW-3	WW-4
1.	Temperature of air ^{0}C	33	33	33	33.5
2.	Color of water sample	greenish	greenish	greenish	greenish
3.	Temperature of water ^{0}C	31.5	31	32	32
4.	pH (35 ^{0}C)	7.0	6.9	6.9	7.5
5.	Taste	Objectionable	Objectionable	Objectionable	Objectionable
6.	Conductivity µS/cm	6700	3100	1760	4180
7.	TDS mg/L	2768	1984	1557	2675
8.	Salinity g/L	7.9	1.6	0.4	2.2
9.	Bicarbonates mg/L	800.0	400.0	110.0	360.0
10.	Carbonates mg/L	Nil	Nil	Nil	Nil
11.	Hardness as $CaCo_3$ mg/L	1140	330.0	120.0	410.0
12.	Dissolved Oxygen mg/L	1.95	0.29	0.44	0.56
13.	BOD mg/L	189.0	104.0	260.0	140.0
14.	Nitrite-N mg/L	2.05	0.14	5.9	BDL
15.	Copper mg/L	0.009	0.0052	0.0055	0.008
16.	Nickel mg/L	0.019	0.013	0.005	0.0172
17.	Iron mg/L	0.116	0.099	0.106	0.2110
18.	Cobalt mg/L	0.0089	0.0076	0.029	0.0115
19.	Manganese mg/L	0.014	0.189	0.054	0.496
20.	Zinc mg/L	0.0279	0.0275	0.0276	0.072
21.	Sodium mg/L	95.0	92.3	50.0	92.0
22.	Potassium mg/L	52.0	38.0	14.0	42.0
23.	Magnesium mg/L	49.2	40.5	17.0	44.4

Wastewater samples collected from the following locations:

WW-1	Pumping Station Pretabad	RD-20
WW-2	Saima Plaza	RD-21
WW-3	Laloo Lashari	RD-26
WW-4	Ghumanabad	RD-30

Water pollution is a serious public health problem in both industrialized as well as underdeveloped countries [10-13]. Disposal of both wastewater and solid waste is not only a source of a number of health problems in the local inhabitant residing on both sides of the canal; it is also polluting the agricultural lands [14]. Gastrointestinal diseases are common in this area and several outbreaks are common in Hyderabad city, especially in summer months. Since Phuleli Canal passes through the Hyderabad city, polluted water may worsen the problem. Laboratory analysis of the waste water and the canal water collected at different locations show increased level of different water pollutants having negative impact on the human health when compared to WHO standards (Table 2 and 3).

Our study recommends a number of mitigation measures to control the serious problem of pollution and encroachment of Phuleli Canal given in the following:

1. The dumping of huge amount of solid waste must be stopped immediately; it may be disposed off at properly identified landfill sites.
2. The buffalo farms and slaughter houses need to be shifted to cattle colony.
3. The encroached areas on banks of canal should be removed and the displaced people should be provided alternative remedy in shape of plots and cash.
4. Protecting or retaining walls along canal from RD-4 to RD-40 on both sides may be constructed and its height of walls should be about two meters for the prevention of encroachment and dumping of solid waste and disposal of wastewater.
5. The treatment plants have already been constructed by WASA at nearby SITE and Latifabad area and also adjacent to the ISRA University. They may be updated for recycling and after treatment, water may be utilized for crops and gardens.
6. The water quality monitoring program should be carried out on regular basis.
7. The water filtration plants should be installed at suitable places for providing safe water to the residences in the command area of Phuleli canal.
8. Basic health facilities should be provided to local people for saving them from water-borne diseases.
9. The awareness program may be carried for the general public as well as those responsible.

5. Conclusion

Population encroachment and waste disposal into the Phuleli Canal is of great concern, as it is polluting the water and it's a source of infectious diseases. Strict regulations, regular monitoring and active involvement of the local community is required for controlling the water pollution. Illegal encroachments and waste disposal points need to removed and offenders must be punished.

Acknowledgements

Authors are grateful to the Irrigation department of the government of Sindh for providing funds, resources and official record to be used in the stud

References

[1] Ghumman, A. R. Assessment of water quality of Rawal Lake by long-time monitoring. *Environmental Monitoring and Assessment*, 2011, 180 (1-4), 115-126. DOI: 10.1007/s10661-010-1776-x

[2] Shakir, H. A.; Qazi, J. I. Impact of industrial and municipal discharges on growth coefficient and condition factor of major carps from Lahore stretch of River Ravi. *Journal of Animal and Plant Sciences*, 2013, 23(1), 167-173.

[3] Furukawa, T., Suzuki, Y. A Proposal for source tracking of fecal pollution in recreational waters by Pulsed-Field Gel electrophoresis. *Microbes and Environment*, 2013 [Early online]. doi:10.1111/j.1365-2672.2010.04918.x

[4] Shafiq, H. B.; Ajaz, M., Rasool, S. A., Bacterial and toxic pollutants in lakes of River Indus. *Pakistan Journal of Botany*, 2011, 43(3), 1765-1772.
[5] Aziz, J. A. Management of source and drinking-water quality in Pakistan. *Eastern Mediterranean Journal of Health Sciences*, 2005, 11(5-6), 1087-98.
[6] Ejaz, N.; Hashmi, H. N.; Ghumman, A. R. Water quality assessment of effluent receiving streams in Pakistan: A case study of Ravi River. *Mehran University Research Journal of Science and Technology*, 2011, 30 (3), 383-396.
[7] Yousafzai, A. M.; Khan A. R.; Shakoori, A. R. Pollution of large, (Subtropical Rivers-River Kabul, Khyber Pakhtunkhwa Province, Pakistan): physico-chemical indicators. *Pakistan Journal of Zoology*, 2010, 42(6), 795-808.
[8] Irrigation department, Government of Sindh http://www.kotribarrage.gov.pk/
[9] Soomro, A., Siyal, A. A., Mirjat M. S, Sial N. B. Seasonal variability of trace and heavy metal concentration in groundwater and its quality for drinking and irrigation purpose under Phuleli Canal Command Area (Sindh), *Pakistan. Journal of Basic and Applied Science*, 2013, 9, 950-61.
[10] Azizullah, A.; Khattak, M. N.; Richter, P.; Hyder, D. P. Water pollution in Pakistan and its impact on public health--a review. *Environment International*, 2011, 37(2), 479-97. DOI: 10.1016/j.envint.2010.10.007.
[11] Dyer, O. Waterborne diseases pose threat in Pakistan as floods strike. *British Medical Journal*, 2007, 335, 66. DOI: DOI: 10.1136/bmj.39272.584688.DB
[13] Qureshi, S.; Mastoi, G. M.; Ghanghro, A. B.; Mastoi, A. W. *Energy Environment and Sustainable Development*, 2012, 191-197.
[14] Yahya, S. M.; Rehman A.U.; Abbasi, H, N. Assessment of seasonal and polluting effects on the quality of river water by using regression analysis: a case study of river Indus in province of Sindh, Pakistan. *International Journal Environmental Protection*, 2012, 2, 10-16.

