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Assessment of canal sediments for agricultural uses

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Abstract

The study was conducted to analyze the extent of heavy metals contamination and bacteriological content in the sediments of Lahore Branch Canal. The main purpose of digging this canal was that the areas of Lahore and Kasur could be irrigated for the means of agriculture. Due to improper drainage systems of industrial sectors and residential areas the level of pollution is increasing in the canal. Sediment samples were collected from three sites located at the canal intersections namely Thokar Niaz Baig, Punjab University New Campus and Dharampura during the canal closure period in 2014 and 2015. The samples were analyzed for heavy metals (Cadmium, Chromium, Copper, Cobalt, Zinc and Iron) by using Atomic Absorption Spectroscopy and the bacteriological content (Total coliform) was analyzed by pour plate method. The metals Zinc, Chromium, Copper and Cobalt were detected in minute concentration. Only the concentration of iron was higher than the recommended limit. According to the Codex Alimentarius standards, all the sediments samples were in safe limits. The Total coliform concentrations for the areas Thokar Niaz Baig, Punjab University and Dharampura were 2500, 5000 and 6000 colonies in year 2014 respectively. In 2015 the colonies of total coliform were found to be 1100, 4130 and 6400 in the same areas respectively. When these sediments are used for agricultural purposes the deposited metals present in them pose harm to the crops. When crops are eaten by human, the metals ultimately get transferred to human.

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Introduction

Water contamination is an important environmental issue in Pakistan. The main source of contamination is the release of untreated wastewater coming from the domestic, industrial, commercial areas into nearby water bodies like lakes, streams, rivers, ponds etc. (Hussain and Sultan, 2013).

In Lahore, issues related to the wastewater have been increasing to a much higher extent which includes the risks to health, environment and natural eco-systems. Contamination of River Ravi has caused serious damage to its flow rate and water quality of the surrounding area. The contaminants in the water systems also find their way into the sediments of the water bodies thus contaminating the sediments and gradually increasing in concentrations over the years. These sediments of the fresh water bodies are also rich in nutrients essential for the growth of vegetation. The sediments are thus considered to be very fertile. Each year during the canal closure period, these sediments are removed from the water bodies and mixed with agricultural soils to improve their productivity. Along with the nutrients, the removed sediments also carry the bioaccumulated contaminants in it thus contaminating the agricultural soils as well (Javed, 2005).

A similar case of discharge of wastewater can be seen in Lahore Branch Canal. It is a serious hazard to the environment and human health. If the discharge of untreated wastewater continues to increase in the same pattern as now then the pollutants and related threats to the groundwater quality and the environment will also increase (Aftab *et al.*, 2011).

Bambanwala Ravi Bedian (BRB) canal is the initiating point of Lahore canal while Bhaipheru is its ending point. The length of the canal is 82 kilometers and can accommodate 350 cusec water. The main purpose of digging this Canal was that the areas of Lahore and Kasur could be irrigated for agriculture. Due to improper drainage systems of industrial sectors and residential areas the level of pollution is increasing in

the canal. Laundry waste, wastewater from human activities, sewage and agricultural waste is posing a serious threat to the canal stream by adding various contaminants in water. Moreover, the waste of unauthorized factories also drains into the canal and various inlets discharge their waste into the canal stream. Because of the increasing pollutants level in the canal, the water is no longer useful for recreational, domestic and irrigation purposes (Aftab *et al.*, 2011).

Various industries situated along the canal discharge their waste in it illegally without any permission from the government. This has a very bad impact on canal water. The Lahore channel receives the excess water from the local manufacturing plants and excess water channels (Hussain and Sultan, 2013). Many micro and macro industries are situated in this area, which discharge their waste in the canal and contribute to the contamination of heavy metals in the sediments and ultimately polluting the surface lining of the canal. Paint and varnishing, pesticides and insecticides, plastic products, rubber products, surgical cotton and bandages, textile made-up, aluminum products, drugs and Pharmaceutical, Electric transformers, glass and glass products, industrial machinery, Fiber glass industries are situated in Thokar Niaz Baig and Dharampura.

Existence of coliform in sediments of Canal bed must be taken very seriously by public health and other regulatory authorities. Canal water can be highly contaminated by pollution from fecal bacteria. Designating such water for human use (recreational and irrigational purposes etc.) is not at all recommended. The coliforms in the water also get deposited in the sediments which when used for agricultural purposes may pose a threat to human health (Amin *et al.*, 2005).

The Lahore Branch of BRB Canal is subjected to the annual cleanup to remove the deposits, dirt, gathered leaves and remains from its bed annually. Sediments are annually removed from the Lahore Branch canal

to be added to the agricultural soils to improve its productivity. The sediments of canal are important because they enrich the soil with nutrients. Sediments are removed from the bottom of Canal and mixed with infertile soil for the purpose of using it in agriculture. Sediments are enriched with humus which promotes vegetation and animal growth. The Canals and Irrigation department is answerable for clearance of substratum known as “Bhal Safai”. The canal is flattened consistently and the rock layers known as ‘Bhal’ are detached throughout this process (Hussain and Sultan, 2013).

Thus the study is meant to assess the suitability of Lahore branch canal sediments for agricultural uses in terms of heavy metal accumulation and Total Coliforms presence.

Materials and methods

Collection of samples

Samples were collected from 3 different areas located along the Lahore Branch Canal as given in Table 1. The samples were collected in plastic bags according to the standard methods for the sampling of sediments as given by Codex. and were sealed. The samples were collected for two consecutive years during the month of December 2014 and December

2015 during canal closure period. All samples were labeled accurately before bringing them to the laboratory. The samples were preserved in refrigerator at 4 °C for further analysis.

Analysis of samples

The sediments were analyzed for the Electrical Conductivity (EC) and pH by EC meter and pH meter respectively. Analysis of Copper (Cu), Cobalt (Co), Chromium (Cr), Zinc (Zn) Cadmium (Cd) and Iron (Fe) was conducted by Atomic absorption Spectrometry according to the standard methods given in Table 2. Total coliforms in the sediments were detected in the sediments by using Mc Conkey Agar Pour plate method.

Results and discussion

The sediment samples collected from the canal were analyzed for the selected parameters. The physical, chemical and biological analysis of sediment samples from the study area are listed in Table 3.

Comparison of parameters with standards

Lahore canal enters the city with a fairly better appearance. On its way as it moves through the city it collects substantial masses of solid wastes. These wastes are of varying characteristic features.

Table 1. Sampling Sites.

Sampling Site	Site conditions
1 ThokarNiazBaig	Commercial / residential, domestic/ industrial waste
2 Punjab University	Residential area, vegetable farming, sewer outlet
3 Dharampura	Residential area domestic and solid waste. Dead animals.

They mainly comprise of leftovers from kitchens, sugarcane and fruit residues and sewage effluent as well. Therefore, the running water is polluted with particulates, organic matter and a myriad of bacterial and other microbial organisms. Most of the bacteria which degrade and decompose the organic matter in the canal are considered to be playing their roles to reduce the turbidity of water. Nevertheless, microbial communities of running waters always remain highly variable and they demonstrate shifting trends(Amin *et al.*, 2005).

In this research, heavy metals and total coliform content was analyzed in sediments of Lahore canal and the results of two consecutive years was compared. In the year 2014, the average pH value of the sediment sample was 6.6 in Thokar Niaz Baig, whereas in year 2015, at the similar sampling site the pH value relatively lowered to 5.86. The average pH of the sample collected from Punjab University New Campus was found to be 6.8 whereas the pH of the sample collected from same area in 2015 was 5.77 which was considerably lower than the previous one.

For the sampling site Dharampura, the results showed that in 2014 the pH was 6.67 while the pH determined for 2015 was 6.3. From the results, it was concluded that the pH of the samples collected from all the three respective sites in 2014 was less than that of 2015. pH from all sampling sites for both years was acidic. Currently there are no standards available for

pH of sediments. Table 2 shows that the electrical conductivity of samples collected from the three respective sections (Thokar Niaz Baig, Punjab University and Dharampura) for the year 2014 was 160 $\mu\text{S}/\text{cm}$, 250 $\mu\text{S}/\text{cm}$ and 145 $\mu\text{S}/\text{cm}$ respectively and 154 $\mu\text{S}/\text{cm}$, 248 $\mu\text{S}/\text{cm}$ and 136 $\mu\text{S}/\text{cm}$ in the year 2015 respectively.

Table 2. Methods used for chemical analysis.

Sr No.	Parameters	Methods
1	Cu	HACH Method 8143
2	Cd	HACH Method 8017
3	Fe	HACH Method 8008
4	Zn	HACH Method 8009
5	Cr	HACH Method 8023

At Thokar Niaz Baig, the concentration of the metals Cr and Co was found to be 2.5ppm and 1ppm respectively in the year 2014. However, the concentration of Cu was 1 ppm at the same site while in next year Cu was not detected. In 2015, the concentration was 2.9ppm and 1ppm for Cr and Co respectively. The Permissible limits for Cr in sediments set by Codex Alimentarius standard is 26ppm and for Cobalt is 50ppm. Hence, the concentration of Cr and Co detected at Thokar Niaz Baig was within the permissible limits. Zn was found

to be null in both years. The concentration of Cr is higher in the samples of 2015 than 2014, due to the lower pH. The lower pH increases the solubility of cationic metals. The pH value at Thokar NiazBaig in 2014 was 6.6 whereas in 2015 the pH lowered to 5.86. So, due to lower pH the concentration of Cr was higher in 2015. The variation in the concentration of metals depends on the organic matter and sand content in sediment. Nazif *et al.* (2006) mentioned that sediments contain more sand and lower values of organic matter exhibit low metals enrichment.

Table 3. Results of the analysis of sediments of both the sampling durations.

Sr. No	Sampling Sites	Sample Color	pH	EC $\mu\text{S}/\text{cm}$	Zn (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Cd (mg/kg)	Total Coliform
(Period 1)											
1	ThokarNiazBaig	Dark Grey	6.6	160	-	2.5	2	1	57	-	2500 colonies
2	Punjab University New Campus	Greyish	6.8	250	5	0.7	1	2.4	56.8	-	5000 colonies
3	Dharampura	Dark Brown	6.67	145	-	0.9	2	-	57	-	6000 colonies
(Period 2)											
4	ThokarNiazBaig	Dark Brown	5.86	154	-	2.9	1	-	56	-	1100 colonies
5	Punjab University New Campus	Dark Brown	5.77	248	4	2.5	2	-	57.5	-	4130 colonies
6	Dharampura	Greyish	6.3	136	-	2	1	-	54.5	-	6400 colonies
EPA guideline for sediments (mg/kg)											
Not Polluted						<25		<25	
Moderately Polluted						25-75		25-50	
Heavily Polluted						>75		>50	...	>6	

The concentration of Zn, Cr and Co was found to be 5ppm, 0.9ppm and 1ppm at Punjab University New Campus during the year 2014, whereas in year 2015 the concentration of metals was 4ppm, 2.5ppm and 2ppm respectively. The concentration of metals found for the year 2015 was considerably higher than the previous year, due to the lower pH. The permissible limit for Zinc in the sediments set by Codex Alimentarius is 120ppm. The metals concentration detected at the Punjab University new Campus was found within the permissible limits. The

metal Cu was not found in the samples of both the years except in year 2014 the concentration of Cu was found to be 2.4ppm. The permissible value for copper set by Codex Alimentarius commission is 16ppm. Hence, the concentration of copper detected from the same site was within the limits of standards. Copper is positively charged particle and having cationic nature, the pH was very low at PU during sampling period 2, as compare to sampling period 1. Lower pH enhances the solubility of positively charged metals (Nazif *et al.*, 2006).

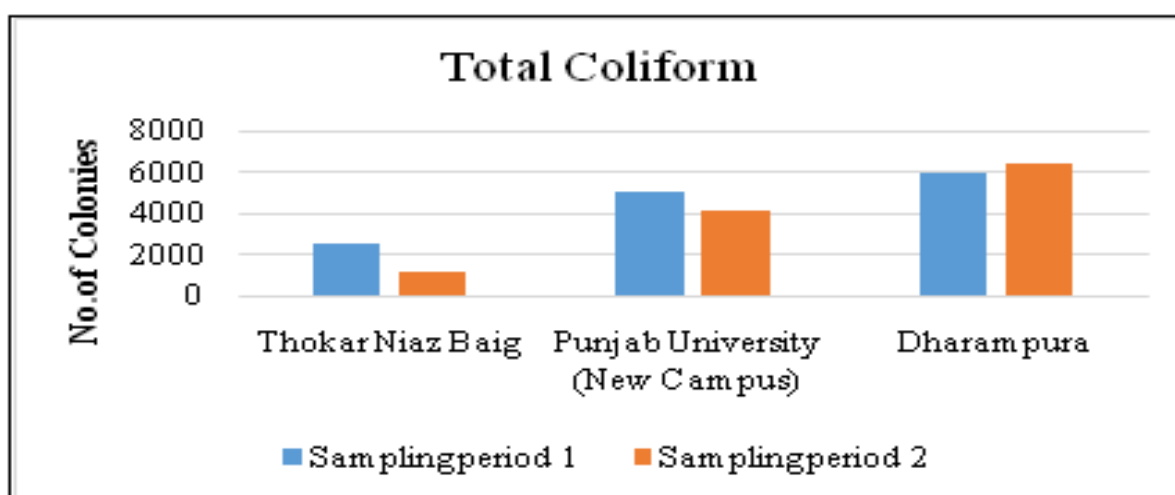


Fig. 1. Colonies of TC in Canal Sediments.

The concentration of Cr and Co was found to be 0.7ppm and 2 ppm in year 2014, whereas in 2015 the concentration of Cr was 2ppm and Co was 1ppm at the sampling site Dharampura. The metals Zn and Cu were not detected in 2014 and 2015. According to the Codex Alimentarius standards it is clear that the resulted values of Cu, Zn, Cr, Co were within the safe limits.

The bioaccumulation of the metals continues to occur gradually with time, gets incorporated to the human food chain as well as the environmental cycle, posing great harm to the human health. Increased heavy metal content negatively affects soil microbial population, which may have direct negative effect on soil fertility. On the other hand, sediments enhance fertility of land. Sediments are annually removed from the bottom of Canal and mixed with the infertile

soil of different cities of Pakistan. Sediments are enriched with humus which promotes vegetation and animal growth. When heavy metal content and bacterial components are present in sediments, it affects the vegetation when combined with other soils of different cities.

The Cu, Co, Zn and Cr are positively charged metals. The metals having cationic nature are more soluble at lower pH, so increasing pH makes the metals less accessible to plants and less likely incorporate in their tissues and ingested by humans (Nazif *et al.*, 2006).

The detected concentration of metals in the study was very minute but all the sampling sites had a low pH. The low pH increases the solubility of metals in sediment, which in turn has detrimental effects on humans.

The metal Cd was not detected from all the sections in both years. Except all the other metals that were found in minute concentration the detected concentration of iron was 57ppm, 56.8ppm and 57 ppm at Thokar Niaz Biag, PU and Dharampura respectively for the year of 2014. In sampling period 2, the concentration was found to be 56ppm, 57.5ppm and 54.5ppm for the respective sites. Currently, there are no standards available for iron in sediments.

The results of a similar study on Begej Canal Sediment showed severe pollution with chromium, copper, cadmium and zinc, whereby the anthropogenic origin of these contaminants was indicated (Dalmacija *et al.*, 2006). If the amount of iron increases in the soil it effects plant growth and cause bronzing and stippling of leaves and even cause death of plant tissues. As the plants are the producers and they are consumed by primary, secondary and tertiary consumers. So, the heavy metals also transfer and bio accumulate in the food chain with ten times more toxic affect (Muhammad *et al.*, 2011).

When sediments are used for agricultural purposes the deposited metals present in them pose harm to the crops. When crops are eaten by human, the metals ultimately get transferred to human food chain. If the solubility of metals in sediment is great it would ultimately pose great harm to the human health, and cause death, whereas the lower dose inhabit the development of young marine animals (Yin *et al.*, 2011).

There are no specific standards for Total coliform in sediment. But they have a direct relationship with the water because if the coliforms are present in water then they must be deposited in the sediments. This ultimately affects the people who would have either direct or indirect contact with water. So, the above stated results show that the Total coliform concentrations for the areas Thokar Niaz Baig, PU and Dharampura were 2500, 5000 and 6000 colonies respectively, in year 2014. While in December, 2015 the colonies of Total coliform were found to be 1100,

4130 and 6400 in the same areas respectively.

Fig. 1 reveals that the large amount of Coliform bacteria was found in the year 2014, because of meat pieces that were thrown by the people as “Sadka”, (a belief to remove the evil eye) which invites the large number of birds. As many birds came there to eat the meat and also excrete feces in the canal which is the major cause of Total coliforms at Thokar Niaz Baig. In addition to that the nearby small industries and residential sites also dumped their waste in the canal which led to an increase of Total coliform bacteria in the water. While, in the sampling period of 2015, the concentration of Total coliform was relatively low.

The variation in the results are due to different reasons as observed at Punjab University sampling site, the concentration of Total coliform was higher in sampling period 1, due to the bulk dumping of organic waste from nearby sites (Punjab University and hostels). Moreover, a very common practice was also observed during the field survey that the pieces of meat were sold and thrown into the canal as a “Sadka” at this site. Due to these factors the organic contents enhance the amount of Total coliform in the sediments. While, in the sampling period 2, the concentration of Total coliform was relatively lowered.

The lowered amount of Total coliform in the year 2015 at Thokar and Punjab University was due to the initial steps taken by the Environmental Department to lessen Canal pollution by reducing the waste dumping practice and government. They also prohibited the meat sellers to sell the meat at canal. Moreover, the workshops and offices were also forbidden by the government to dump their waste in the canal.

At Dharampura, the amount of Total coliform increased in both years as compared to other sampling sites because of the 20 inlets of municipal drains that directly fall into the Canal at Dharampura and the Punjab University sites. These drains include

the organic waste from the nearby residential areas and dead animals like hens, dogs and cats etc. also being thrown into the canal.

The bacteria's and heavy metals in the sediments are not only confined to the sediments but are also somewhat diluted in the water. When the water uses for other purposes such as fishing, boating, domestic or for irrigation it may cause health risks. Some waterborne pathogenic diseases can occur due this contaminated water such as typhoid fever, bacterial gastroenteritis, hepatitis A and skin diseases (Weinstein *et al.*, 2008).

Hence, by comparing the concentrations of bacterial colonies in the sediment samples, a conclusion was drawn, that the water in the canal of the sampling areas does not comply with the limits required for the water to be effective for various purposes i.e. for recreation and other domestic uses, as this canal is a free treat for the unprivileged communities of the city during hot and scorching long summers.

People find shelter from the hot weather by swimming into the canal for hours. Hence, these areas were discharged with more fecal and organic waste material that promotes bacterial growth. Bacteria's do not cause the disease directly but their high quantities show the presence of disease causing agents. The presence of Total Coliform in water body would pose the high risk to human health. Swimming can be very dangerous in this contaminated water because the bacteria can enter the body through mouth, nose, ears or the cuts in the skin. Hence they cause fever, nausea, and stomach cramps.

Conclusion

It is concluded that with the increase in industrialization and commercialization a lot of solid waste is being discharged into the canals that contribute to a greater extent of occurrence of heavy metals and bacterial growth not only in the water but also in the sediments of water bodies. The selected heavy metals were in permissible limits of the Codex

standards but heavy metals may cause health effects if they accumulate for a longer period of time. On the other hand, the concentration of bacteria was found to be immense in the sediments of the canal. These polluted sediments when mixed with agricultural soils to improve their productivity causes poses a threat to human health. So the industries and the commercial areas should design some suitable technology to discharge and dispose off their wastes.

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