Research Paper

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Toxicological Indicators of the Sewage Waste of Islamabad City

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Classical bacterial indicators and organic matter contents were analyzed for sediment samples and the suspended particles collected from the sewage waste of Islamabad city. The suspended particles were most affected by proximity of point source and sewage overflows, which were associated with significant increases in the concentration of faecal coliforms, faecal streptococci and *Clostridium perfringens* spores. In contrast, only faecal coliform counts significantly increased in sediments with increasing distance from the point source. Sewage overflow again resulted in increased concentrations of faecal coliforms, faecal streptococci and *Clostridium perfringens* spores in suspended particulate matter. Faecal coliforms were identified as the most useful indicator of faecal pollution as only this indicator correlated significantly to the organic matter contents ($r = 0.88$, $r_s = 0.93$) for sediment samples. The amount of organic matter in suspended particulate matter was not significantly different but a gradual increase in the organic matter with an average value of 2 to 3% was detected in the sediment samples with increasing distance from the point source. Our findings indicate a high level of faecal pollution in Nullah Leh, particularly coliforms, in amounts several magnitudes higher than the standards permit. It is concluded that minimization of hazards lies only in the treatment of sewage waste prior to its discharge in open environment.

Key words: Faecal coliform, faecal pollution, toxicology, sewage waste

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Introduction

Domestic sewage and industrial effluents are the significant contributors to water pollution. It originates chiefly from households, public facilities and businesses. Industrial wastewater however, has a wide range of pollutant concentrations compared to domestic sewage. The composition of the wastewater varies in accordance with the types of the industrial units. Sources upon which water quality standards can be based include extensive studies on the effects of pollution in receiving water as well as existing standards from other countries or states (UNEP, 1999). The application of water quality standards for wastewater depends on its eventual end up, whether it is pond, lake, stream or river. This criterion becomes more significant if the water body acting as a recipient of wastewater is used for commercial purpose. For example, the UNEP/World Health Organization (WHO) standard for shellfish harvesting water is a maximum of 10 faecal coliforms 100 ml^{-1} for 80% of samples taken. Shellfish contamination is associated with typhoid fever, cholera, viral hepatitis (Tsai *et al.*, 1998) and many other gastro-enteric conditions (Ferguson *et al.*, 1996).

The Islamabad-Rawalpindi city sewage is a combination of domestic and industrial waste which eventually ends up in a 10km long Nullah Leh, finally falling into River Soan. Besides effluent water, domestic sewage adds further toxicity. The facilities regarding the treatment of industrial liquid waste prior to discharge in outside environment are deplorable, nor did the city has any faecal sludge management program. Existing conditions of the Leh's water pose threats of increasing toxicity as well as risk of disease prevalence. A devastating rain flood that hit the twin cities recently (July, 2001) has further aggravated the situation.

In this context, this work was aimed to assess only the toxicological indicators in order to highlight the level of sewage contamination. Our investigation was mainly focused on faecal bacteria, which are considered to be the best indicators of faecal pollution (Miller *et al.*, 1998). Studies regarding status of contamination or toxicity of wastewater require a number of other parameters. However, we primarily emphasized on sediment and suspended matter faecal counts.

Materials and Methods

Sediment samples were collected in the direction of flow of wastewater from the source point. In total, 6 samples were obtained, within 250m from the point source, keeping a distance of 50m in between. Wastewater and sediment samples (up to 15cm deep) were simultaneously collected in a column and suspended particulate matter was separated from the water by filtration. Organic matter content was estimated for sediment and suspended solids as described by Bodineau *et al.* (1998). The agar-based medium (LES Endo Agar and KR Streptococcus agar) was used for colony forming unit (CFU) coliform bacterial counts for sediment and suspended particulate matter (Franson, 1975).

Values obtained for bacterial count were tested statistically against the organic matter for the same site by establishing a correlation for both the parameters. Correlation values were calculated by Product Moment Correlation Coefficient (r) as well as Spearman's Rank Correlation Coefficient (r_s). The later correlation was applied for minimization of error and to bring the data at comparable scale. However, to plot line of regression on scatter graph, correlation coefficient "r" was used (Hyams, 1997).

Results and Discussion

Analysis of the sediment samples showed a gradual increase in the values for organic matter contents for all the sites with increasing distance from the point source. Increase in the amount of organic matter for sediment samples were statistically significant. However, difference in the increase in organic matter for suspended particulate for all the 6 sites appeared non significant (Table 1). It seems that water flow in Leh was considerable enough to cause dispersion of particulate matter. Moreover, the first 2 sites reflected less than 0.5% particulate organic matter, compared to other 4 sites. This suggested that sampling spots near the point source are receiving the wastewater in enormous amount but the continuous addition moved particulate suspensions ahead before they settled down. Studies devoted to organic matter investigation in flowing water especially for particulate matter, reflect a similar trend where comparatively low organic matter detection appeared in relation with water velocity (Bodineau *et al.*, 1988).

The other parameter studied i.e., bacterial indicators, reflected a similar trend of gradual rise in cfu counts for sediment samples, with increasing distance from the point source (Table 2). In both suspended matter and sediment samples, faecal coliform were observed consistently. On the other hand, out of 6 samples collected, faecal streptococci counts were found in 4 samples of suspended matter and also in 4 samples of sediments (Table 2). The frequent occurrence of coliforms over streptococci led us to believe that coliforms are the most useful indicators of sewage or faecal pollution. The world wide prevalent nature of coliforms in wastewater is well documented (Ferguson *et al.*, 1996; Miller *et al.*, 1998). Mostly treated effluents contains the upper limit of 10,000 faecal coliforms 100 ml (Hodgson and Larmie, 1999) and our observed lower limit is fairly high indicating that coliform concentration in Leh is beyond the acceptable standards of environment and health requirement.

As regards the comparison of organic matter and bacterial counts, the Product Moment correlation coefficient and Spearman's Rank correlation coefficient revealed positive values for sediment samples. Increase in distance from point source, showed similar effects on both the parameters. The positive relationship is evident from the line of regression presented in Fig. 1, where a high level of correlation ($r = 0.88$) was observed for sediment samples. It seems that two factors have played a vital role in the establishment of strong correlation between organic matter amount and faecal bacterial increase along point source distance. Firstly, the sediment samples in the vicinity of point source were under the influence of sewage overflow casing little or no descending of suspended particles. Hence low values for both the parameters were obvious. Secondly, away from the point source (samples 5 and 6), reduced rate of sewage flow enhanced the settle down of suspended particles. Thus a gradual rise in bacterial counts and the amount of organic matter in sediment samples was observed (Table 1 and 2). The same factors emerged as the prime reason for negative correlation for suspended particulate (Fig. 2). Comparison of correlation values for sediment samples and suspended particles revealed that positive correlation ($r = 0.88$) is more compelling than the negative one ($r = -0.79$). Therefore, it seems that the results of sediment samples are reflecting the existing conditions in more realistic terms.

The bacterial counts obtained in this investigation manifest a considerable level of faecal pollution. As water of the Leh is not in use for any other purpose, therefore, the Environmental Protection Agency (EPA) standard for coliform counts which is 200 colonies for treated sewage waste and 1000 colonies for water used only for boating purpose, does not appear to apply here. However, lack of treatment facilities for domestic sewage and industrial effluents is presenting a high risk of pollution. Non-implementation of wastewater-related environmental laws by appropriate authorities in this regard has further spoiled the situation. Various studies have indicated the importance of waste treatment management particularly pathogen removal (Almasi and Pescod, 1996; Vis *et al.*, 1998) and improvement of waste quality prior to

Table 1: The amount of organic matter (%) in suspended particulate matter and sediment samples collected at the same spot from a point source at uniform distance

Sample	Distance from Point Source (meters)	Organic matter (%) Suspended Particulate	Organic matter (%) Sediment
1	05	0.48a ± 0.02	1.19a ± 0.4
2	50	0.45a ± 0.01	2.04a ± 0.6
3	100	0.52a ± 0.05	2.36b ± 1.2
4	150	0.57a ± 0.08	2.87b ± 1.1
5	200	0.51a ± 0.11	3.54c ± 1.4
6	250	0.56a ± 0.09	3.14b ± 0.8

Mean ± SD of organic matter content, values with different letters in the column are significantly different (n = 3) ($P < 0.01$)

Table 2: Faecal bacterial counts obtained from colony forming units (cfu) for suspended matter and sediment samples collected at the same spot from a point source at uniform distance.

Sample	Point source distance (m)	Bacterial indicators ($cfu100\ ml^{-1}$) Test Bacteria	Suspended matter	Sediments
1	05	Faecal coliforms	60000	15000
		Faecal streptococci	7000	N.D
		**Clostridium perfringens* spores	N.D	N.D
2	50	Faecal coliforms	53000	15000
		Faecal streptococci	5000	1000
		Clostridium perfringens spores	+ve	+ve
3	100	Faecal coliforms	40000	20000
		Faecal streptococci	3000	1000
		Clostridium perfringens spores	N.D	N.D
4	150	Faecal coliforms	25000	40000
		Faecal streptococci	N.D	N.D
		Clostridium perfringens spores	N.D	N.D
5	200	Faecal coliforms	20000	45000
		Faecal streptococci	3000	1500
		Clostridium perfringens spores	N.D	+ve
6	250	Faecal coliforms	20000	52000
		Faecal streptococci	N.D	1000
		Clostridium perfringens spores	+ve	+ve

* Spores presence was noted by indicating +ve sign. N.D stands for not detected.

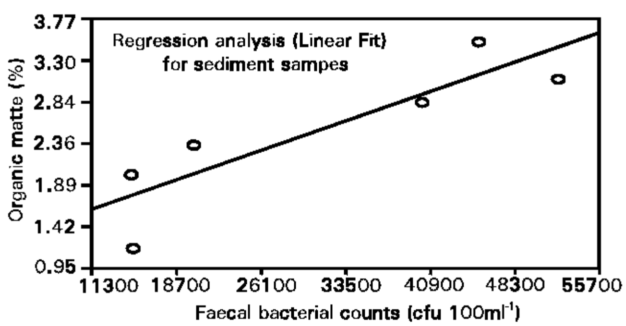

Fig. 1: The correlation between organic matter and faecal bacterial counts represented by scatter graph showing positive correlation among each other with increasing distance from point source (SE = 0.44, r=0.88).

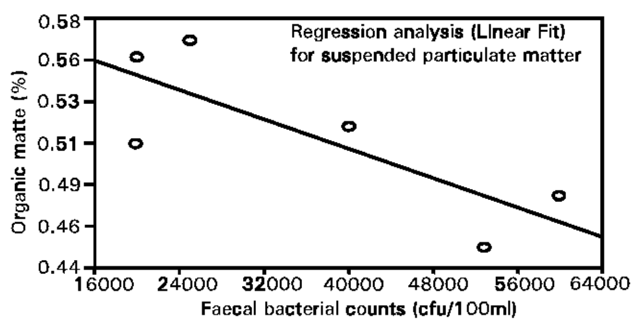

Fig. 2: The correlation between organic matter and faecal bacterial counts represented by scatter graph showing negative correlation among each other with increasing distance from point source (SE = 0.03, r = – 0.79).

discharge in water body (Gallichand *et al.*, 1998). This becomes more significant, if water body receiving waste, passes alongside dwellings. In cases like the present one, the effort to disinfect the sewage waste or its reuse for agriculture purpose becomes extremely vital (Liberti *et al.*, 1999). Constant addition of sewage and industrial waste to the waters of streams flowing through densely populated urban areas eventually leads to levels of toxicity harmful to the human beings. A rational approach in this regard is required to continuously monitor the toxicity levels of urban liquid waste so as to minimize potential risks.

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