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COLIFORM BACTERIAL POLLUTION IN RAWAL LAKE, ISLAMABAD AND ITS FEEDING STREAMS / RIVER

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Total coliform and fecal coliform are indicators of drinking water quality. The presence of fecal coliform in water indicates contamination with fecal materials of man and other animals. This paper documents the population of total coliform colonies as well as fecal coliform contamination in Rawal lake, which is one of major source of drinking water supply to inhabitants of Rawalpindi, and its feeding streams (mainly Kurang River and three perennial streams) flowing in the administrative jurisdiction of the capital city, Islamabad, Pakistan. Coliform bacteria in Rawal lake and feeding streams water was determined by membrane filtration technique. The results indicated that E. Coli population in four streams (input waters) feeding the Rawal Lake ranged from 25 - 57 (mean 36) fecal coliform per 100 mL. The Kurang River, one of the feeding streams, hosted the largest population of fecal coliform (57 fecal coliform per 100 mL). The highest population of fecal coliform (105 fecal coliform per 100 mL) in Rawal Lake surface water was observed at the confluence of Kurang River and the Lake in the vicinity of village “New Ampler”. While in the Rawal Lake water columns, it ranged from 12 - 65 (mean 25) fecal coliform/ 100mL. The measured levels of fecal coliform bacteria are much higher than the maximum permissible levels for drinking water as recommended by WHO and US-EPA (No fecal coliform in drinking water). It is concluded that the indiscriminate amount of pollution from domestic sewage and poultry industry has seriously affected the biological quality of stream waters and the Rawal Lake waters.

Keywords: Rawal lake, Dam, Stream, Coliform, Korang, Rawalpindi, Islamabad

1. Introduction

The term “Coliform” refers to rod shaped, non-spore forming, Gram negative bacteria. They aid in the digestion of food. A specific subgroup of this family of bacteria is the fecal coliform bacteria, the most common member being Escherichia coli which passes through the fecal excrement of humans, livestock and wild life. These organisms may be separated from the total coliform group by their ability to grow at elevated temperatures and are associated only with the fecal material of warm-blooded animals [1,2]. Fecal coliform bacteria can enter water reservoir through direct discharge of waste from mammals and birds, from agricultural and storm runoff, and from untreated human sewage or through individual home septic tanks can become overloaded during the rainy season and allow untreated human wastes to flow into drainage ditches and nearby waters. They can also enter water through agricultural practices such as allowing animal wastes to wash into nearby streams during the rainy season, spreading manure and fertilizer on fields during rainy periods, and allowing livestock watering in streams can all contribute fecal coliform contamination.

Fecal coliform bacteria indicate the presence of sewage contamination of a waterway and the possible presence of other pathogenic organisms. Presence of fecal colifom shows that the source water may be contaminated by pathogens or disease producing bacteria or viruses, which can also exist in fecal material. Some waterborne pathogenic diseases include ear infections, dysentery, typhoid fever, viral and bacterial gastroenteritis and hepatitis A. The presence of fecal coliform tends to affect humans more than it does aquatic creatures, though not exclusively. While these bacteria do not directly cause disease, high quantities of fecal coliform bacteria suggest the presence of disease causing agents. The presence of high numbers of fecal coliform in a water sample signifies that the water may have

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received fecal matter from one source or another. Although not necessarily agents of disease, fecal coliform bacteria may indicate the potential presence of disease-carrying organisms, which live in the same environment as the fecal coliform bacteria [3,4]. Fecal coliform testing is one of the nine tests of water quality that form the overall water-quality rating in a process used by the US Environment Protection Agency (US EPA) [5].

The city of Rawalpindi has an estimated population of about 2.5 millions. Urbanization is taking place at the rate of about 4.5 %. About 70 % of the population lives in the rural areas. Agriculture is mainly rain fed. The rainfall in the area is quite erratic, 79 % falls from June to September and ranges upto 1750 mm. The rapid growth of population has caused severe problem of clean drinking water supply & demand in the Rawalpindi city. In addition to groundwater reserves, Rawal Dam is one of the main sources of water supply for the Rawalpindi City. The Rawal dam is situated between Rawalpindi & Islamabad (Figure 1). It was constructed in 1960 by damming the River Kurang for the purpose of supplying drinking water to the city of Rawalpindi. The height of Rawal Dam is 133.50 feet. Its live storage capacity is about 43000 Acre-feet. Pond area is the dam is 2023 Acres and the spillway capacity of about 82000 cusecs. On the basis of design it was calculated that the dead storage of 4500 Acre-feet of this dam would be exhausted after 73 years [6].

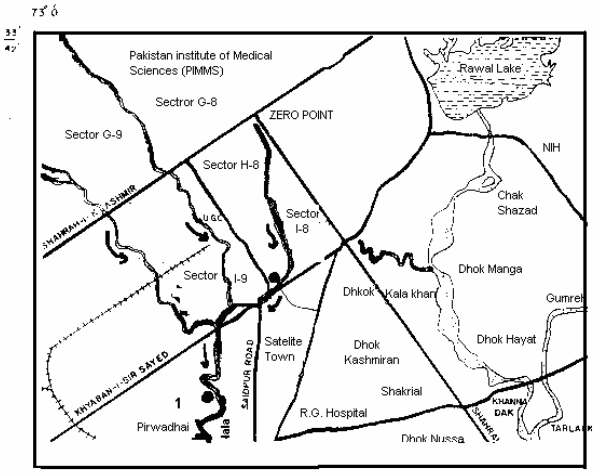

Figure 1. Location of Rawal Dam

There are generally four major potential sources of pollution in Rawal Lake: (i) sewage from human settlements; (ii) Deforestation and agricultural activities, (iii) waste dumping sites and (iv) activities related to tourism & leisure around the lakes. The first three sources of pollution contribute to the Rawal Dam via four streams feeding the dam. The most serious of these pollution sources is the waste from human settlements. The adjacent parts of the catchment areas of the Rawal Lake are experiencing extensive development, predomi-nantly housing schemes and, therefore, the number of people living within the Rawal lake catchment is significantly increasing over the years. Consequently, this practice is causing concerns with regards to degradation of water quality of streams feeding the Rawal Lake. There is relatively little industrial activity within the catchment, stone crushing in the Bhara Khao area has mainly ceased, and the agriculture activities do not appear to be very significant. Poultry farming has been identified as a particular concern. It has been estimated that approximately 170 poultry farms having about 360 poultry sheds lie within the catchment area [7]. Some basic arrangements for disposal of poultry waste have been made but these are unlikely to significantly delay or prevent the inflow of pollutants into the lake. Leisure activities are significant potential source of pollution. The tourist park at Chattar lies adjacent to the Kurang River and has large number of visitors (average 2000 on week days, over 20,000 on Sundays and holidays are reported). At present, collectively, a substantial proportion of human wastes, poultry wastes and other waste end up in the Kurang River.

Due to presence of the stream network and the short distance involved, the domestic sewage and poultry wastes from catchment area apparently reach Rawal Lake very quickly. This inventory/disposal of untreated wastes directly into the lake environment is posing a serious problem of water quality deterioration in the lake. Once such contaminated waters are released to public water supply lines, these can seriously contaminate the water reservoirs/tanks in the Rawalpindi city. Ultimately, the consumers of this biologically contaminated water may face sever health problems [8,9]. In order to manage clean water supply in Rawalpindi, assessment of chemical and biological quality of Rawal Lake and its feeding streams and rivers is imperative.

In the present investigation, a quantification of the Total Coliform and Fecal Coliform population is

made to assess the biological quality of water in Rawal Lake and its major/ minor streams that flow round the year.

2. Materials and Methods

2.1. Sampling locations

Feeding Streams/River: Figure 2 shows the location of various sampling points in the Rawal Lake. There are many small drains and streams which feed the Rawal dam from time to time depending upon rainfall intensity, run off, extent of base flow, and spring discharge. However, the main input water sources (streams and river) sampled in the present investigation are marked as "ST" in Figure-2. The Stream St-1 crosses the Murree Road near "Rawalpindi 17 km Milestone". It flows throughout the year and therefore, it serves as a regular source of water supply for the Rawal Lake. It carries mixture of spring water and wastewater originating from the Diplomatic Enclaves around the American Embassy in Islamabad. Water samples were collected under the bridge from a location across the stream channel, which represented maximum flow. The Stream St-2 crosses the Murree Road near "Rawalpindi 18 km Milestone". It flows throughout the year and serves as a regular source of water supply for the Rawal Lake. It carries mixture of spring water and wastewater. Its discharge is less than the Stream-I. Water samples were collected under the bridge from a location across the stream channel, which represented maximum flow. The Stream St-3 is a very minor stream. It crosses Murree Road near "Rawalpindi 21 km Milestone" close to the Anwar Nursery. It carries mainly the spring water & partly base flow originating from the residential area before Bhara-Kohao during the rainy season. The stream flows throughout the year but its discharge is extremely small as compared to Streams 1 & 2. Water sample was collected downstream about 100 meters off Murree Road. The Stream St- 4 called Kurang River acts as the major source of water supply for the Rawal Lake. The river was tapped at Simly Road Bridge about 2 km away from Bhara-Kohao off Murree Road. This river carries mixture of spring water, seepage water, flood water, waste water originating from poultry farms, irrigation fields on gentle hill slopes, residential areas located along the course of the river.

The Rawal Lake was sampled at three representative locations covering the inflow and outflow cross-section of the lake. The entrance of feeding streams in the lake was very shallow. Therefore, the lake top surface water sample was collected only just after the confluence of Kurang River in Rawal Lake, where it was possible to drive the motorboat. However, depth water samples were collected from two locations in the lake: (i) Middle of Rawal Lake; and (ii) Close to Spill Way.

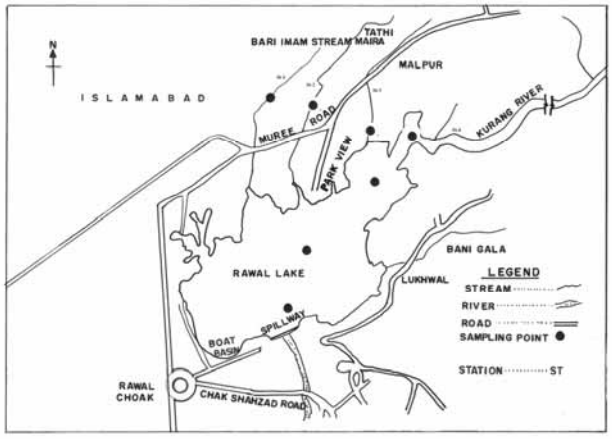

Figure 2. Sampling locations of Rawal Lake and feeding streams

2.2. Water sampling

The streams were approached through Murree Road and the stream water samples were collected manually with a clean plastic beaker. A conventional motorboat was used to approach the sampling locations in the Rawal Lake. A submergible water pump (commonly known as Russian pump) was attached to 0.5 inch dia rubber pipe was used to collect Depth water samples (depth profile). High quality pre-cleaned and pre-sterilized plastic bottles (250 mL bottles with lined cap and septum) were used for sample collection. Two water samples were collected from each location. Samples were stored at temperatures less than 12 ^{o}C in ice coolers during transfer to the environmental laboratory for coliform bacterial analysis.

2.3. Coliform bacterial analysis

Coliform bacterial population was determined using a Paqualab^{TM} incubator [10]. Two types of Coliform populations were measured. One type involves Fecal Coliform bacteria, which is a typical indicator of sewage pollution, as this bacterium

Table 1. Coliform population in streams (input water sources) feeding the Rawal Lake, Islamabad.

Sample Code*	Sample Location/ Stream Flow Description	Sampling Date	Depth (m)	Coliform Population	
				Total	Fecal
St-1	Stream near "Milestone Rawalpindi-17 Km" on way to Murree	11-06-2009	Surface Water sample	55 ± 1	25± 2
St-2	Stream near "Milestone Rawalpindi-18 Km" on way to Murree	11-06-2009	Surface water sample	35± 2	27± 2
St-3	Stream near "Milestone Rawalpindi-22 Km" on way to Murree close to Anwar Nursery	11-06-2009	Surface water sample	102± 2	35± 2
St-4	Kurang River at Bhara Kaho-Simly Road bridge	11-06-2009	Surface water sample	59 ± 3	57± 2

* St: Stream/River

Table 2. Biological analysis of water in Rawal Lake, Islamabad

Sample Code	Sampling Date	Depth (m)	Total Coliform	Fecal Coliform
RAWAL LAKE WATER JUST AFTER KURANG RIVER ENTRY				
RE-0 (S)	11-06-2009	surface	105± 3	65± 4
RAWAL LAKE SPILLWAY ZONE PROFILE				
RSW-1 (DP)	11-06-2009	surface	56± 2	52± 2
RSW-2 (DP)	11-06-2009	4	59± 2	56± 3
RSW-3 (DP)	11-06-2009	7	27± 1	16± 3
RSW-4 (DP)	11-06-2009	10	7± 3	0
RAWAL LAKE MIDDLE ZONE PROFILE				
RM-1 (DP)	11-06-2009	surface	65± 3	25± 2
RM-2 (DP)	11-06-2009	3	25± 1	12± 2
RM-3 (DP)	11-06-2009	5	8± 2	0
RM-4 (DP)	11-06-2009	7.5	4± 1	0

R = Rawal Lake, E= Rawal Lake entrance from Kurang River side

M = Lake middle zone profile, SW= Spillway profile, DP= Depth water profile

originates in sewage waste and waste water (effluents). This type of Coliform has typical health concerns in case of drinking water. The second type comprises of Total Coliform, bacteria which contains the Fecal Coliform as well as Coliform bacteria commonly found in soil [11]. Both these types of Coliform have typical incubation temperatures and can be distinguished from one another. For the measurement of Coliform bacterial population, accurately, 100 mL of each type was filtered separately from each sample to collect the Coliform bacteria onto a 0.45 μ nitrocellulose membrane filter paper (Gelman Filtration products). Coliform bacteria are > 0.45 μ in size and are retain on filter paper. Thereafter, the membrane filter papers were put onto absorbant pads (Gelman Filtration products, England) soaked in Laurie Sulphate bacterial broth (ELE, international Ltd, England) and placed in an aluminium petri dish. The dishes were placed in the Paqualab^{TM} incubator (ELE, paqualab universal incubator, ELE Internationational, England) for 16- 24 hours. One set of dishes were incubated at 44 ^{o}C for determination of the Fecal Coliform bacterial population, while the other set of dishes of same sample were incubated at 37 ^{o}C for determination of the Total Coliform bacterial population. Afterwards, the dishes were removed and the membrane filters were studied with a magnifying glass/colony counter for yellow spot colonies, which confirm presence of Coliform bacteria in water samples.

3. Results and Discussion

Tables 1 & 2 indicate the Coliform bacterial population for water samples collected from input water sources (feeding streams) and three representative locations covering the inflow and outflow cross-section of the lake. Analysis of water samples collected from input water sources (streams feeding Rawal Lake) shows that Total Coliform levels are in the range from 55 to 102 per 100 mL water. The higher values of Total Coliform are observed for the Minor Stream (located at 22 km milestone). Fecal Coliform levels for the input water sources range between 25 to 37 Fecal Coliforms/100 mL. The higher values of Fecal Coliform are observed for the Kurang River water.

Total Coliform bacterial population in the Rawal Lake surface waters range from 56 to 105 per 100 mL for the Total Coliform and from 25 to 65 per 100 mL for the Fecal Coliform. For water column depths of more than 1 meter, the bacterial population ranges from 4 to 59 per 100 mL for Total Coliform and from 0 to 56 per 100 mL for Fecal Coliform. Figures 3 and 4 show variation in Coliform bacteria in water columns. It is important to note that for the lake middle zone water column, the Fecal Coliform population approaches a value of 0 per 100 mL below a depth of 3 meters, whereas, for the Spillway Zone water column, the Fecal Coliform population approaches 0 at depths below 7 meters. Unlike the other conventional water quality parameters, fecal coliform bacteria are living organisms. They multiply quickly when conditions are favourable for growth and die in large numbers when they are not. Because bacterial concentrations are dependent upon specific conditions for growth and these conditions change quickly, fecal coliform bacteria counts are not easy to predict. For example, although winter rains may wash more fecal matter from urban areas into a lake, cool water temperatures may cause many of the organisms to die. Direct exposure to sunlight is also lethal to bacteria, so die-off may be high even in the warmer water of summer time.

According to the Washington Water Quality Standards WAC 173-201A-030, freshwaters rated AA (extraordinary) shall not have coliform levels exceeding 50-colonies/100 mL and not have more than 10% of all samples exceeding 100-colonies/100 mL (for Class A excellent - 100 colonies/100 mL and less than 10% of all samples exceeding 200 colonies/100 mL). The levels of Coliform bacteria are much higher than the maximum permissible levels for drinking water. Ideally drinking water should not contain any Fecal Coliform organism, 1 count per 100 mL is acceptable, 2-4 satisfactory, 4 count is considered as unsatisfactory, above 4 counts is considered as suspicious and 10 to 100 is considered as unsatisfactory [12].

The presence of high population of Fecal Coliform organisms in Rawal Lake water indicates that large amount of untreated domestic and poultry wastes are drained in the lake. High levels of fecal-indicator bacteria in rivers and streams can indicate the possible presence of pathogenic (disease-causing) microorganisms. Cholera, typhoid fever, bacterial dysentery, infectious hepatitis, and cryptosporidiosis are some of the well known waterborne diseases that spread through water contaminated with fecal matter. Eye, ear, nose, and throat infections also can result from contact with contaminated water.

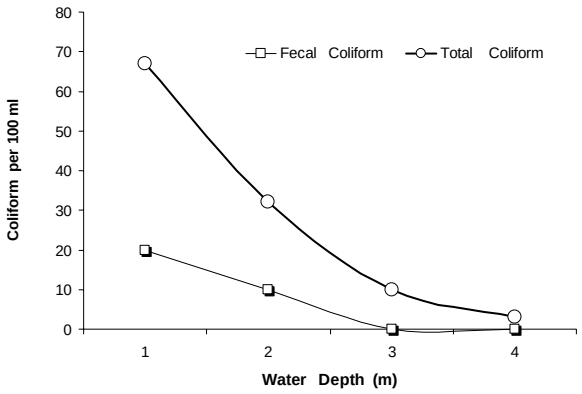

Figure 3. Depth profile of coliform population in the middle zone of rawal lake.

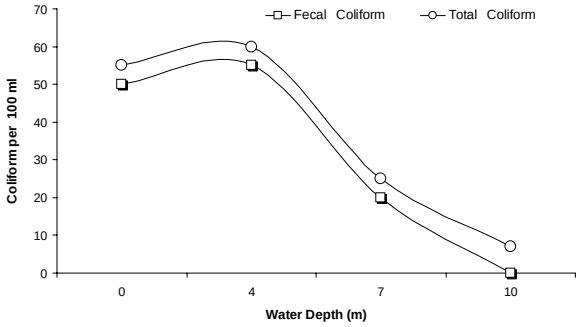

Figure 4. Depth profile of coliform population in the spillway zone of Rawal lake

4. Conclusions

The indiscriminate inventory of pollution from domestic sewage and poultry industry has seriously affected the biological quality of stream waters and the Rawal Lake waters. The results show that Rawal lake is contaminated with fecal and total coliform. The study indicates that there should be a regular programme for biological water quality monitoring of streams feeding the Rawal Lake and the Lake water itself including the water filtration plant. There is an urgent need for community participation to motivate and make realize the Community Health Departments in Rawalpindi/ Islamabad, Rawalpindi Municipal Corporation (RMC), Capital Development Authority (CDA/Islamabad), Pak-Environmental Protection Agency (Pak-EPA), Islamabad; and the Environmental & Urban Affairs Division (Govt. of Pakistan) to endorse and follow adequate remedial strategies for waste management in the Rawal Lake catchment zone and to make these procedures effective for improvement of biological quality of feeding streams for water quality conservation of Rawal Lake.

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