Intestinal Pathogens and Microbial Pollution of Urban Lakes - A Case Study on Yellamallappa Chetty Lake, Bangalore, India

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ABSTRACT

This study was conducted to assess the microbial contamination of Yellamallappa Chetty lake located near Krishnarajapuram, which is under severe stress due to agricultural runoffs, untreated sewage from the city and also from the surrounding residential layouts, and industrial discharges from the nearby units. As a result of these discharges, socio-economic and environmental services to surrounding community have severely deteriorated causing harm to the lake water quality as well as exacerbating health risks to local people in the surrounding areas who depend in part or entirely on the Yellamallappa Chetty lake for food, water, farming, etc. The series of biochemical tests conducted on the water samples collected from four major pollution source points between January and May 2007 around the lake showed the presence of intestinal pathogens such as Escherichia coli, Salmonella, Shigella, Klebsiella ranging from 1000-1200cfu/10 ml. To further support the above study, an attempt was made to assess the health effects and socio-economic impact on the surrounding residential community on the extent and magnitude of the microbial infections caused by these pathogens through a questionnaire survey. Seventy Per Cent (70%) of the respondents confirmed the persistence of several cases of microbial infections, particularly among the fishermen community. The above results indicate the severe nature of microbial pollution in the lake and the need to establish benchmarks for restoration of the lake water quality to improve the ecological profile of the lake as well as enhancing environmental health indices for the local population.

Keywords: water pollution; fecal contamination; pharmaceutical industry

INTRODUCTION

Water suitable for drinking and domestic use, free from diseases producing microorganisms and chemical substances deleterious to health is called potable water. The contaminated water containing domestic and industrial wastes is called non-potable water. There are standard bacteriological procedures to determine potability of water. The intestinal discharges of human beings and animals may gain entry into water meant for domestic supplies. The bacteria that gain entry in this way are known as enterobacteria especially E. coli - designated collectively as coli forms. Thus presence of any of these bacteria in water is evidence of fecal pollution. Coli forms particularly E.coli are constantly present in human intestine in large numbers. It is estimated that billions of these bacteria are excreted by average person in one day. These organisms generally live longer in water than intestinal pathogens and therefore easily detected compared to real pathogens. However, the presence of coli forms shows danger of fecal pollution and consequent hazard of contracting diseases through pathogenic organism (Vijaya Ramesh: 2005).

Water is essential for life and arguably the most important natural resource. Aquatic environment in addition to providing water for drinking, provide necessary resources for agriculture, mining, industries etc. Thus protection and preservation of this environment are vital for continuation of life (Raina. M. Maier: 2006). Tanks are part of an ancient tradition of harvesting and preserving the local rainfall and water from streams and rivers for uses, primarily for agriculture and drinking waters. Often a tank was constructed across a slope so to collect and store water by taking advantage of local mounds and depressions. Karnataka has 36,672 tanks with approximately 69,000 ha in 27 districts. 90% of these tanks have area of less than 40 ha. The actual irrigated area is estimated to be not more than 2,40,000 ha (35% of the total potential).

Bangalore is one of the rapidly growing metropolitan cities in India; but due to rapid urbanization and a high rate of population growth there has been a drastic increase in demand for housing and other amenities which has resulted in breaching of several lakes and conversion of open spaces into buildings. The number of lakes still surviving has been drastically reduced to 81. Discharge of sewage and other waste water and dumping of solid wastes in to the storm water drains pollute many of existing lakes. Many individuals and communities discharge excrements directly into the
lakes without proper treatment or disposal systems, thus ignoring the fact that such materials frequently contain bacteria capable of causing diseases.

Pathogenic bacteria transmitted by water and waste water include Salmonella, Shigella, Escherichia- coli, Klebsiella, (APHA, 1992). The microbial content can also render water unsatisfactory from other technical and aesthetic points of view. The objectionable microorganisms in water also damage several other materials including equipments exposed to them. Bacteria occur in appreciable numbers on skin, gills and in intestinal contents of fish. The level of contamination reflects geographical areas in which they live and their feeding habits. For example, bottom feeding fish usually have highest level of contamination. Fishes caught in lakes often carry wide range of pathogenic microorganisms contributed by sewage, land runoff, etc. It is generally accepted that internal organs and muscle tissues of healthy live or freshly caught fish is sterile. The spoilage of fish food is due to activities of bacteria normally present in living fish which after its death penetrate into tissue and decompose them. (Nandi,N: 2000). Salmonella typhi is a very clear example of the main agents of the outbreak of water borne diseases in India such as occurred in 1905. This prompted a series of systematic studies by which were later published in memoirs of the then British India Government by Semple and Greig in 1908. By culturing methods, Semple and Greig isolated common types of S. typhi . Paratyphoid organisms were also present and S. Paratyphi-A was more common than S. Paratyphi-B as against situations in Europe at time where S. Paratyphi-B was prevalent.

OBJECTIVES AND SCOPE OF THE STUDY

This study was conducted to assess the microbial contamination of Yellamallappa Chetty lake located near Krishnarajapuram, which is under severe stress due to agricultural runoffs, untreated sewage from the city and also from the surrounding residential layouts, and industrial discharges from the nearby units. There were two principal objectives. First was to carry out characterization of strains, their identification, confirmatory and count tests using a series of techniques including membrane filtration method and biochemical tests such as Hydrogen Sulphide, Oxidation Fermentation Test, Lactose Fermentation, Oxidase Test, Indole Test, Methyl Red Test, Voges Proskauer, Simon’s Citrate Test, Triple Sugar Iron Agar Test, and Urease Test.

Secondly, a questionnaire survey was commissioned to study the patterns of microbial infections and accessibility of other environmental health services. This included finding out about the quality of available water sources, nature of water utilization, perceptions on lake water quality and pollution sources as a whole, microbial infections caused as a result of eating food (fish, crops,) and other activities related to waters of Yellamallappa lake; also in understanding the mode of medication and access to extension medical officers in the community. Therefore the main objectives were as follows:

- To examine the presence or absence of Enterobacteriaceae members like E-coli, Klebsiella, Salmonella and Shigella in Yellamallappa Lake.
- To determine the bacterial load of the above pathogens in Yellamallappa lake.
- To conduct questionnaire survey on selected groups of people living immediately around Yellamallappa lake in order to assess the extent of microbial infections in the fishermen and household communities.

MATERIALS AND METHODS

About the Study Area

Yellamallappa Chetty tank is located near Krishnarajapuram, Hosakote taluk, Bangalore rural district, road towards north east of Bangalore city, which is about 20km away from the city center. The lake lies in outskirts of Bangalore, adjacent to Cipla pharmaceutical industry. National highway– 4 which joins further to Hosakote transects the lake cutting it into two major parts – the wetland side and the waterspread zone. Yellamallappa Chetty tank lies between 13°12’20” to 13°21” North latitude and 77°42” to 77°44’56” East longitude covering an area of 110 hectares (Photo 1).

The Climate of the Study Area

The Climate of Bangalore district as a whole is classified as seasonally dry tropical with conductive temperature. The highest average maximum is 14°C. The mean monthly is lowest at 24% and relative humidity is highest at 85%. The mean annual rainfall is 859.6mm spread over approximately 57 days per year.
The Drainage and Socioeconomic Patterns of the Study Area.

Yellamallappa Chetty tank is basically a rain fed tank with major inflow from surrounding channels coming from North West direction. The major outflow point is towards the south east of the lake; just north of the Whitefield rail crossing zone. The western shore line of the lake is bordered with old industrial units whose area has now been converted to make-shift slump dwellings. These dwelling enclose the only fish landing site and hence fish market just at the corner where National Highway 4 begins to intersect the lake. The southern parts are mainly occupied by agricultural fields and dispersed settlements while eastern banks are bordered with industrial units including the present CIPLA pharmaceutical industry. For the local residents, fishing is the major economic activity in the area, the fish-catch from this lake is also highly supplied to the surrounding market areas and other parts of Bangalore city (Photo 2). Other mode of socio-economic activities includes irrigation, fodder, harvesting of minor products such as flowers from the wetland side of the lake; cattle washing, etc. A central power transmission line runs directly overhead across the lake parallel to the National Highway. Some agricultural lands are now being converted into new residential layouts.

Pollution Source Points Affecting the Lake

Field observation carried out in this study reveals a series of heavy pollution source points immediately onto the lake shore line. Although the major inflow point from the North West contains already severely degraded quality of water (This water has to pass through a natural wetland zone on the northern side of the National Highway 4) it is the discharge of the effluents directly into the main lake zone on the south of the National Highway 4 that are the causes of severe domestic and industrial pollution zones. For example, the eastern shoreline brings in the voluminous bulk of waste water and other industrial discharges from the surrounding industrial units. Open drain pipes running from these industrial units have been located. The western shoreline is bordered with make shift-slum dwellings, fish landing site, and the fish market just at the vicinity of the fish landing site (Photo 3 & 4). This is also a point where a mixture of waste water from the fish market and open toilet drains from the nearby dwellings converge. Further south new residential layouts continue to crop out with great speed exacerbating encroachment problem around the lake basin. Sewage pipes from surrounding areas have also been found emptying their effluents into the lake. In the midst of it are agricultural lands whose fertilizer and manure laden wastes leaches down to the periphery of the lake’s shoreline.

Sample Collection and Preparation

Based on the major inflow sources of pollution as explained above, a total of four major sampling points were selected. The first- near the fish market where the mixture of fish waste effluents and open toilet drains entered the lake; the second sampling point was under the first bridge of the National Highway 4 where the first North-West inflow carrying silt and sediments enters and mix with the lake water about 50 meters away from the fish market. The third sampling point was between the
second bridge of the National Highway 4 where the second inflow also carrying silt and sediment mix with the lake water in the middle of the lake directly on its way to the southern outlet. Lastly, the fourth sampling point was selected near the outlet of CIPLA pharmaceutical industry. Samples were collected by grab sampling method using APHA standard methods on microbial analysis.

The samples were collected in suitable bottles that had been previously cleaned and rinsed in distilled water and sterilized by autoclaving before mounted for sampling; In collecting samples extreme care was taken to avoid contaminating parts of bottle coming in contact with water. The bottles were stoppered without removal of protective cover. The Bottle was filled to three quarters of their capacity. All the samples were stored in cool ice box and immediately brought to the laboratory within one hour.

**Laboratory Analysis and Techniques:**

*Characterization of Strains and their Identification Counting, Isolation and purification of bacteria carried out Standard methods from {APHA, 1992 & Aneja.K.R, 1996} were used to determine Enterobacter species {E-coli, Klebsiella, Salmonella, and Shigella}*

**Total Bacterial Count by Membrane Filtration Technique (MFT)**

0.5 ml of sample was diluted to 10 ml and filtered through membrane filter (0.45 m pore size, 47 mm diameter). The membrane filters were placed on sterile, labeled Petri plates filled with sterilized MUG (Methyl Umbelliferyl-β-D Glucoronide), Salmonella agar or Brilliant green agar, MacConkey agar, EMB (Eosin methylene blue) agar and incubated for 24 hrs at 37°C. Following incubation the number of colonies per disc was counted using a digital colony counter (MUG agar is a selective agar, which is used for the gram negative Lactose fermenter basically E-coli).

**Gram Staining**

A loopful of 24 h culture was suspended in a drop of sterile diluents on a clean grease-free slide; with the help of inoculating needle a uniform smear was made. The smear was air dried; heat fixed by passing over the flame several times, care was taken to ensure that the slide did not get heated up. The staining was carried out following the recommended procedure (APHA, 1992).

**Isolation by Quadrat Streaking Method**

Representative colonies were selected on basis of size, colour, and consistency from MUG agar, EMB agar, MacConkey agar, Salmonella or Brilliant green agar. Then isolated colonies were transferred to nutrient agar plates by Quadrat streaking method and incubated for 24 hrs at 37°C and sub cultures were used for various biochemical tests conducted according to Himedia Manual for the identification of the species. Bacterial strains were identified following the procedure described in Himedia Manual; APHA, AWWA and WPCF; 1992, Bergley’s Manual of Determinative Bacteriology (1990) and Aneja., K.R Experimental Manual for Microbiology (1996).

**Biochemical Test Conducted for Identification of Colonies**

**Hydrogen Sulphide Production Test**

Strips of Whatman No. 1 paper were soaked in 10% lead acetate, dried and inserted between the tubes and cotton wool plug of the slope culture of the organism. Browning or blackening of the slip indicated the production of Hydrogen sulphide. Also Lead acetate agar was prepared following Colin’s Methods (Collins, 2001) - plated, streaked with suspected colonies of Salmonella and incubated at 37°C for 24 h. Brown/Black end point indicated production of Hydrogen sulphide.

**Oxidation/Fermentation Test**

The tubes containing lactose broth and an inverted Durham’s tube were inoculated with a loopful of inoculum from 18 h culture and incubated for 24 h at 37°C (APHA, 1992). A change from Blue to yellow and gas formation in Durham’s tube indicated positive oxidation and fermentation.

**Lactose Fermentation**

The samples were plated on MacConkey medium, on which the colonies of lactose fermenting bacteria appeared as pink colonies and others remained pale (Photo 5 & 6). By this method, it was possible to distinguish between colonies of true intestinal pathogens like Salmonella and Shigella which do not ferment lactose, and the common intestinal commensals, such as Escherichia and klebsiella, which ferment it. The identity of the pale colonies as Salmonella or Shigella was however, confirmed by the test.

**Oxidase Test**

Strips of Whatman No. 1 were dipped in 1% aqueous solution of NNN”N” – tetramethyl P – Phenyle diamine dihydrochloride. The suspected colonies from nutrient agar plates were touched by these strips. The positive reaction was indicated by purple coloring of the strip within 10 seconds.
Indole Test

The reagents were prepared using the described procedure (APHA, 1992). Five ml of medium was inoculated from pure culture and incubated at 35°C for 24±2h. Subsequently 0.2 to 0.3 ml of reagent was added shaken well and allowed to stand for 10 minutes. A dark red layer on the amyl alcohol surface constituted a positive Indole test and original colour of the reagent, a negative. An orange colour probably indicates the positive presence.

Methyl Red Test

The methyl red tests for acid production from glucose, the bacteria. The metabolic reaction is demonstrated by gas production. The methyl red and Voges – Proskauer tests are related and are useful in differentiating the members of coli form group (APHA, 1992). Ten ml of medium from pure culture was incubated and inoculated with the test organism at 35oC for five days. To five ml of culture, five drops of methyl red was added, incubated for 48 h. the retention of stain was recorded as methyl red positive and a change to distinct yellow as negative.

Voges Proskauer Test

This test indicates acetoin production by some coliform bacteria on peptone glucose medium. The reagents were prepared according to standard procedure (APHA, 1992). Five ml of medium was inoculated and incubated for 48 h at 35±0.5°C one ml of culture, 06ml napthol solution and 0.2 ml KOH were added. Development of pink to crimson colour within 5 minutes constituted a positive test. Tubes developing copper tinge were discarded.

Simon’s Citrate Test

This procedure tests the ability of bacteria to utilize citrate as the source of carbon. The liquid media was inoculated with a needle, incubated at 35±0.5°C. The blue end point indicated positive reaction.

Triple Sugar Iron Agar Test

T.S.I agar was stabbed at centre of butt and streaked on the slope of tube with a young culture of the test organism. The tubes were incubated at 37°C for 24 to 48 h. The glucose fermentation is shown by a yellow butt and a red slant.

Urease Test

To tubes containing five ml of melted, cooled (50°C) Christensen’s agar 0.5 ml of 20% urea were added and solidified in a sloped position. After the production of Urease by organisms the urea splits with the formation of ammonia and turning the phenol red indicator purple. All bacteriological media and other chemicals used were obtained from Hi-Media Pvt Ltd., Bombay, India.

House-Hold Questionnaire Survey

A total of 10 house hold heads from each village around the lake constituted the sample. The total houses surveyed were fifty. The respondents mainly the heads of their respective families were interviewed by means of a questionnaire which requested information from respondents on household characteristics, population, age distribution etc., extent of dependency on the lake water and other services and general attitude and adverse impacts of tank water. The selection of the households was randomly done considering those who are dependent on the tank water for agriculture. The questionnaires were both semi structured and open and also specifically targeted the fishermen.
community. They included keys for obtaining information on sources of water (potable and domestic usage), perceptions regarding lake water quality, incidences or outbreak of microbial infections to the community as a result of consuming lake water, food poisoning cases such as that related to fish caught from the lake, mode of medication and visits by extension medical officers.

RESULTS AND DISCUSSION

Heterotrophic plate after 24 hours of incubation and analysis confirmed the presence of E.coli, Salmonella, Shigella, and Klebsiella in all the selected sampling points. The results are shown in Table 1, Fig 1. Escherichia coli count ranged from minimum 1037 to maximum 1530 cfu/10ml with an average of 1263 cfu/10ml. Salmonella ranged from minimum 92 cfu/10ml to maximum 130 cfu/10ml with an average of 108 cfu/10ml. Shigella’s count ranged from minimum 7 cfu/10ml to maximum 25 cfu/10ml with an average 14.75 cfu/10ml. Klebsiella ranged from minimum 6 cfu/10ml to maximum 36 cfu/10ml.

Table 1. Total Plate Counts after 24 hrs of incubation

<table>
<thead>
<tr>
<th>Sps</th>
<th>S1 cfu/10 ml</th>
<th>S2 cfu/10 ml</th>
<th>S3 cfu/10 ml</th>
<th>S4 cfu/10 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-coli</td>
<td>1037</td>
<td>1225</td>
<td>1260</td>
<td>1530</td>
</tr>
<tr>
<td>Salmonella</td>
<td>112</td>
<td>92</td>
<td>98</td>
<td>130</td>
</tr>
<tr>
<td>Shigella</td>
<td>7</td>
<td>12</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Klebsiella</td>
<td>25</td>
<td>9</td>
<td>6</td>
<td>36</td>
</tr>
</tbody>
</table>

Analysis confirms heavy presence of the E.Coli, Salmonella, Shigella, and Klebsiella on Sampling Point 4 which is near the Pharmaceutical industry. The total pathogen count here is at 1727 cfu/10ml with E.Coli at 1530 cfu/10ml, about eighty-eight (88.59%) per cent of the all the pathogen colonies counted with an average 431.75 cfu/10ml. Salmonella were at 130 cfu/10ml; Klebsiella at 36 cfu/10 ml; and Shigella at 25 cfu/10ml. The colony trend in Sampling Point 4 followed the following pattern: E.Coli > Salmonella > Klebsiella > Shigella.

Figure 1. Total Plate Count for Intestinal Pathogens after 24 Hour Incubation
Figure 2. Domicile status, family type, food habit of people in village surrounding Yellamallappa Lake

Sampling Point 3 which corresponds to the area under the second National Highway 4 bridge in the middle of the lake had a second total pathogens count ranging at 1379 cfu/10 ml with an average 344 cfu/10ml. Fig 1. E.coli formed ninety-one per cent (91.3%) of the total pathogens in the zone with 1260 cfu/10ml. Salmonella count was 98 cfu/10ml; Shigella’s count was at 15 cfu/10ml and Klebsiella at 6 cfu/10ml. The trend followed E.coli > Salmonella > Shigella > Klebsiella.

E.coli colonies in Sampling Point 2 located between the Fish Market and the first National Highway 4 Bridge were at 1225 cfu/10ml. This was about Ninety Two Per cent (91.5%) of the total pathogens counted (1338 cfu/10ml). Salmonella, Shigella, and Klebsiella were at 92 cfu/10ml. 12 cfu/10ml, 15 cfu/10ml, and 6 cfu/10ml respectively with the following trend: E.coli > Salmonella > Shigella > Klebsiella.

The results of the Sampling Point 1 near the Fish Market confirms the microbial pollution of the surrounding water. E.Coli in this case was found to be 1037 cfu/10ml (about 87.8% of the total pathogens count of 1181 cfu/10 ml with an average 295.25 cfu/10ml per colony. E.coli > Salmonella > Klebsiella > Shigella

The results of the Biochemical tests carried out using Simon’s Citrate Test, Urease, Gelatin Hydrolysis Test, Hydrogen Sulfide Test, Casein Hydrolysis, Lactose, Mannitol, Sucrose, Starch, MR Test, VP Test, and Indole are presented on Table 2. Seven (7) out of Twelve (12) or about 58.3% of the Biochemical tests for E.Coli mentioned above indicated differentially the presence of pathogens. Two tests – Mannitol and MR Tests confirmed presence of E.Coli in the samples. Five Biochemical tests (Urease, Casein Hydrolysis, Hydrogen Sulfide from TSI, Starch and VP Test) did not show results.

Biochemical tests for Klebsiella showed that 9 Biochemical tests or 75% of the total tests (with the exception of Hydrogen Sulfide and Casein Hydrolysis tests) showed presence of differential number of pathogens in the samples. Klebsiella was confirmed with Mannitol test. Salmonella was detected by 4 or one third (33%) of the total biochemical tests. Mannitol and MR tests confirmed the presence of Klebsiella in the tested samples. Shigella was confirmed with Mannitol and MR Test. Only indole test proved differentially the presence of pathogens. All other tests did not produce any results.

Table 2. Showing Biochemical Tests Conducted to Detect the Intestinal Pathogens of Yellamallappa Chetty Lake

<table>
<thead>
<tr>
<th>Biochemical test</th>
<th>E.-coli</th>
<th>Klebsiella</th>
<th>Salmonella</th>
<th>Shigella</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simmon’s citrate</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>-</td>
</tr>
<tr>
<td>Urease</td>
<td>-</td>
<td>D</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gelatin hydrolysis</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>-</td>
</tr>
<tr>
<td>H₂S. from TSI</td>
<td>-</td>
<td>-</td>
<td>d</td>
<td>-</td>
</tr>
<tr>
<td>Casein hydrolysis</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lactose</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>-</td>
</tr>
<tr>
<td>Mannitol</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Sucrose</td>
<td>D</td>
<td>d</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Starch</td>
<td>-</td>
<td>d</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MR test</td>
<td>+</td>
<td>d</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>VP test</td>
<td>-</td>
<td>D</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indole</td>
<td>D</td>
<td>D</td>
<td>-</td>
<td>D</td>
</tr>
</tbody>
</table>

(d = Some strains catalase negative, D = Differential.)

The above results indicate the level of microbial pollution in Yellamallappa lake. The result of the questionnaire survey around the study area are presented on Tables, 3,4,5,6, and 7 respectively. The findings from this study show that generally people living around Yellamallappa Chetty lake have been suffering from microbial infections for some time now. Ninety- percent of the respondents (90%) were native to the area as compared to the Ten per cent respondents who were migrants from other places. Seventy per cent (70%) of these respondents were from the nuclear family; and seventy five percent (75%) were non-vegetarian, indicating that they consumed fish caught from the lake on a daily basis (Fig 2). Sixty per cent (60%) of respondents said that they were now forced to visit a doctor twice a month due to their persistent illnesses.
Table 3. Domicile Status, Family Type, Food Habit of People in Villages surrounding Yellamallappa Chetty Lake as taken from the Questionnaire Survey

<table>
<thead>
<tr>
<th>Domicile status</th>
<th>Family type</th>
<th>Food habit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native</td>
<td>Migrant</td>
<td>Nuclear</td>
</tr>
<tr>
<td>90%</td>
<td>10%</td>
<td>70%</td>
</tr>
</tbody>
</table>

Table 4. Showing the Mode of Medication and Frequency of Visiting Doctor in villages surrounding Yellamallappa Chetty Lake as taken from the Questionnaire Survey

<table>
<thead>
<tr>
<th>MODE OF MEDICATION</th>
<th>FREQUENCY OF VISITING DOCTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctor</td>
<td>Pharmacy</td>
</tr>
<tr>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>25%</td>
<td>60%</td>
</tr>
<tr>
<td>15%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Table 5. Percentage Proportion of Common Diseases in Villages surrounding Yellamallappa Chetty Lake as taken from the Questionnaire Survey

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Percent</th>
<th>Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Septicaemia</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>Vomiting</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Not noticed</td>
<td>10%</td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Showing the level of Awareness on Water Pollution in Yellamallappa Chetty Lake as taken from the Questionnaire Study

<table>
<thead>
<tr>
<th>Awareness of pollution</th>
<th>Source of pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td>70%</td>
<td>20%</td>
</tr>
<tr>
<td>10%</td>
<td>Fertilizer</td>
</tr>
</tbody>
</table>

Table 7. Showing the Level of Literacy Rate and Age Distribution on the sampled population of the villagers in Yellamallappa Chetty Lake as taken from the Questionnaire Study

<table>
<thead>
<tr>
<th>AGE / LITERACY</th>
<th>18-28</th>
<th>29-39</th>
<th>40-50</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illiterate</td>
<td>25%</td>
<td>25%</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>25%</td>
<td>35%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>High School</td>
<td>25%</td>
<td>35%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>College</td>
<td>25%</td>
<td>5%</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Twenty-five per cent (25%) said they would visit a doctor once a month. Only 15% of the respondents said that they were never bothered with such cases of microbial infections and would visit doctors whenever they would feel sick (Fig 3). Forty Five per cent (45%) of the respondents said they suffered from Septecemia, while Thirty Five Per Cent (35%) said they were often taken ill with diarrhea (Fig 4).

In some cases, about ten per cent of the respondents (10%) said their illnesses caused them to suffer from severe vomiting in some occasions (Table-5, Fig 4) while consuming fish from lake. Fifty – five per cent (55%) of the respondents said they were forced to visit a Doctor personally when sick. Forty Five per cent (45%) said they would rather refer their cases to local pharmacies for on-the-counter treatment.

Were they aware of what level of pollution that Yellamallappa lake was in? About seventy per cent (75%) of respondents agreed that they were aware of this situation. Seventy percent (70%) of the respondents said that they had witnessed industrial units such as the pharmaceuticals discharging or flushing their effluents into the lake. (Table-6, Fig 5).

The literacy levels among the respondents from age group 18-28 was 100%, people from age group 29-39 were 75 % literates and people from age group 40-50 only 10% of them were literates (Table-7, Fig 6). No matter the literacy rate people in the area are aware of pollution of lake and the fishermen were found to be affected by Septicaemia and diarrhoea which are symptoms of disease caused by intestinal pathogens like Escherichia-coli, Salmonella, Shigella and Klebsiella.
Figure 3. Mode of medication, frequency of visiting doctor

Figure 4. Percentage proportion of common diseases in a village surrounding Yellamallappa Lake.

Figure 5. Percentage of Awareness of Pollution and Source of Pollution
CONCLUSION

Pollution has become necessary evil in our daily life, more so in case of developing countries. In developed countries associated problems are being tackled in convincing way to ensure that no significant damage occurs in habitat. However in case of developing country like India, the situation is different. The various investigation and surveys made including inventory of polluted stretches of river have brought to light several instances of severe pollution. In Bangalore several hundred major and minor industries have come in last few years. The waste discharged from there units are likely to produce unwanted effects, by affecting both biotic and abiotic factors. Contaminated water has frequently been described as vehicle of infection. The most important aspect of water quality is its freedom from contamination with fecal matter and other pathogenic microorganisms. Therefore the primary objective of present study is to bring on record true picture on bacterial contamination occurring in Yellamallappa Chetty Lake whose water is being used for various purposes, such as fishing, washing and irrigation.

The investigations and questionnaire method clearly indicated source of contamination as pharmaceutical industry and agriculture runoff. Hence density of bacteria in water has reached unsafe levels from the view point of pisciculture and several people are found to be suffering from diseases caused by there pathogens which are under my study. From the result it is concluded that Escherichia coli, Salmonella, Shigella and Klebsiella count was high in sample 4. Because pharmaceutical industry near sample site 4 is letting out its waste into lake. This can be controlled by waste water treatment method by industries situated near the lake. Sample 1 is found to have the second highest bacterial count because the dead and rotten fishes from the fish market are thrown into the lake near sample site 1 which has to be avoided. Sample 3 and Sample 4 is found to have third and fourth highest bacterial count respectively. This is because the lake is bifurcated by a National Highway 4 and there is a inlet on the southern side of the lake. Through this inlet pollutant from other lakes and agricultural run off enters the lake through the bridge under the National Highway 4. Agricultural runoff is also one of the pollutants to the lake which can be controlled by adopting organic farming and artificial recharge of groundwater. The rejuvenation of adjacent lakes helps in preservation and conservation of Yellamallappa lake.

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