CHAPTER III

MICROBIAL QUALITY

Introduction

The potential of water is to hide the microbial pathogens and causing subsequent illness is well recorded for both developed and developing countries (Wright et al., 2004). Water is regarded as one of the nutrients, although it yields no calories. It forms part of the structural composition of cells and is an essential component of diet (Baloch et al., 2000). It is a universal solvent with supplies from wells, springs, rivers, boreholes, lakes, streams, etc. During passage through the ground it dissolves minerals in rocks, collects suspended and particulate matter particularly organic as well as pathogenic microorganisms from faecal matters. Majority of rural water sources for drinking are still the traditional ones that are dams, wells, rivers, streams, ponds which might harbour water borne and vector borne diseases (Fenwick, 2006). Water has been associated with transmission of waterborne disease such as diarrhea, cholera, typhoid fever etc., (Oyeku, 1998). These and other factors make the raw water unfit for drinking without treatment (Raymond, 1992). United Nations estimated that 1.2 billion people lacked access to potable water worldwide (Oyeku et al., 2001). The World Health Organization (WHO) has estimated that up to 80% of all sickness and disease in the world is caused by in adequate sanitation, polluted or unavailability of water (Cheesbrough, 1984).

Many developing regions of the world suffer from either shortage of water or the readily accessible water sources are heavily polluted (Kazmi, 2004). Human health in tropical countries is generally rated by many indices as poor. A comparison of likely fate of a thousand babies born alive in poor developing countries and
advanced ones reveals that a quota (250 out of a 1000) given birth to fail to reach their fifth birthday. One hundred and fifty (150) die in the first year of life, seventy (70) in the second year; and relatively few survive into old age, with large numbers, probably 5 - 10% overall deaths in many of such places, particularly among very young children, due to water borne and water related diseases (Bradley, 1972). The main reason of mortality is due to microbial contamination in water. It may occur when a well is situated within 200 feet of the source of contamination (Smith, 1981). Surface water is found in lakes, streams and shallow wells which contain microbes, these microbes may reflect the air through which rain has passed, or the sewage treatment facility located along rivers bank (Alcamo, 1997) are the main cause of microbial propagation. The extent of treatment needed therefore is determined by the quality of the raw water source (Macrea et al., 1993).

To control and prevent these microbial population needs full examination of water supply embodies several lines of investigations including topographical, chemical, biological and microbiological. Each line of investigation has it’s uses and indication. Microorganisms in water of high significance include most of the ingested pathogens, present a serious risk of disease. Their elimination should be given high priority. e.g.: Escherichia- coli, Salmonella, Shigella, Vibrio cholera, Yersinia enterocolitica, Campylobacter jejuni, Giardia, Cryptosporidium, Entamoeba histolytica and Darcumuculus (WHO, 1997). Among these coliform group includes a broad diversity in terms of genus and species, whether or not they belong to the Enterobacteriaceae family. Most definitions of coliforms are essentially based on common biochemical characteristics. In Standard Methods for the Examination of Water and Wastewater (APHA et al., 1998), coliform group members are described as:
1) All aerobic and facultative anaerobic, Gram negative, non-spore-forming, rod-shaped bacteria that ferment lactose with gas and acid formation within 48 hrs., at 35° C (multiple-tube fermentation technique) or

2) All aerobic and many facultative anaerobic, Gram-negative, non-spore-forming, rod-shaped bacteria that develop a red colony with a metallic sheen within 24 hrs., at 35° C on an Endo-type medium containing lactose (membrane filter technique).

The use of the coliform group as an indicator of faecal contamination is subject to strict governmental regulations (Table - 69). *E. coli* is the most common coliform among the intestinal flora of warm-blooded animals and its presence might be principally associated with faecal contamination. Therefore *E. coli* are not allowed in drinking water. The US Environmental Protection Agency (EPA) has approved some regulations and guidelines for drinking water (Table - 69).

These coliform organisms are also used as the indicator of sewage contamination (Tate and Trussel, 1997). *Escherichia coli* are recognized as an indicator of the fresh water system which receives the wastes from the municipal and corporation waters (Grunnet, 1975). They are used as the bacteriological tool to measure the occurrence and intensity of faecal contamination (Amutha and George, 1988). This predominant aerobic bacteria mostly found in the large intestines of man and animals. Geldreich (1990) inferred that the faecal pollution in water with *Salmonella* from warm – blooded animals, is common and not from the man alone.

It has been reported that the study of TPC and coliform bacteria is the first step in the determining the magnitude of bacterial pollution in a lake (Rao and Burnison, 1976). The people tend to defecate near field, water bodies like rivers, ponds, rocky pools, lakes and waste land (Davis, 1977). Hence the runoff water is
responsible for the pollution of surface waters. Severe pollution in rivers, ponds, rocky pools and lake is caused by the urban runoff water (Tafuri, 1975; Burgess and Olive, 1976; Rao and Burnison, 1976; Prakasam, 1991; Prakasam and Joseph, 2000). The four main types of clinical syndromes caused *Escherichia coli* are (i) Urinary tract infection (ii) Diarrhoea or gastroenteritis (iii) Pyogenic infections (abscesses, peritonitis, cholecystitis and meningitis) and (iv) Septicaemia.

Microbiological testing will show whether these pollutants are present or not. In the context of drinking water, Olivieri (1983) has recommended that different indicators be used when different aspects of pathogen behaviour are of interests, e.g., indicator of faeces, treatment efficiency, or post treatment contamination. Coliform concentrations in natural waters have been used as an indicator of potential pathogen contamination since at least the 1890’s (Whipple, 1917). Until recently, Coliforms have been considered to be less sensitive to environmental stresses than enteric pathogens. Accordingly, Coliforms were believed to be more persistent in natural waters and, therefore, a ‘safe” or conservative index of potential pathogen levels.

Several methods for coliform detection: the multiple-tube fermentation technique, the membrane filter technique and the presence/absence test (including the ONPG-MUG test). Afnor (1990) has approved the multiple-tube fermentation technique and the membrane filter technique. These methods have limitations, such as duration of incubation, antagonistic organism’s interference, lack of specificity to the coliform group and a weak level of detection of slow-growing or stressed coliforms. Indeed, depending on the environmental system, only a small portion (0.1–15%) of the total bacterial population can be enumerated by cultivation- based methods (Amann *et al.*, 1990). The proportion of non-culturable bacteria may be affected by unfavorable conditions for bacterial growth during culturing or by their entry into
viable or active but non-culturable states (VBNC or ABNC) (Roszak and Colwell, 1987; Joux and Lebaron, 2000; Colwell and Grimes, 2000). Keep this all background the present investigation deals with MPN (Most Probable Number) Five Tubes technique to enumerate the total coliform and faecal coliform and for the impact and significant causative microorganisms from the sampling stations (S\textsubscript{1} – S\textsubscript{10}) of riverine system.

**Materials and Methods**

**Sample Collection**

The bacterial analysis of water was done as per standard methods recommended by APHA, 1998. Sample collection is a very important part of river study because conclusions drawn are based only on the testing of collected samples. The purpose of taking samples is to obtain information, which in some way typifies the aquatic system from which samples are drawn. Grab sampling procedure was adopted as recommended by Standard Method for microbiological analysis Samples were collected during on monthly basis, for a period of twenty two months from August 2008 to May 2010.

There were ten sampling locations such as Banjari(S\textsubscript{1}), Tilauthu(S\textsubscript{2}), Indrapuri(S\textsubscript{3}), Sikaria(S\textsubscript{4}), Aurangabad(S\textsubscript{5}), Dehri (S\textsubscript{6}), Daudnagar(S\textsubscript{7}), Bikramganj(S\textsubscript{8}), Jehanabad(S\textsubscript{9}) and Dinapur(S\textsubscript{10}) . Water samples for microbiological examination, were collected in non-reactive borosilicate glass bottles of 500 ml capacity each that had been cleansed and rinsed carefully, given a final rinse with distilled water and sterilized. Samples were taken from the river by holding the bottle near its base in the hand and plunging it, neck downward, below the surface. Then turning the bottle until neck points slightly upward and mouth is directed toward the
current. The sampling bottle was not filled up to the brim and 20 mm to 30 mm space was left for effective shaking of the bottle. Microbiological analysis of water samples was started as soon as possible after collection to avoid unpredictable changes in the microbial population (Gaudy, 1998). The collected samples were immediately transferred to the laboratory with care. Then the water samples were preserved (Table-1) and analyzed (Table-2). Then the following presumptive test/ Most Probable Number (MPN), confirmed test and completed test were been done.

**Microbiological analysis**

**Presumptive Test / Most Probable Number (MPN)**

Five sets of lactose broth containing Durham’s tube were divided into three parts and each was inoculated with 10ml, 1ml and 0.1ml of aliquots sample. Turbidity and production of gas bubbles were observed after incubation at 37ºC for 24 to 48h. The number of organisms in the original culture was estimated from a MPN Determination Chart to determine the MPN index and 95 % confidence limits of combinations of positive results with five tubes per dilution (10 ml, 1.0 ml,0.1 ml) (Benson 2002).

**Confirmed Test**

The positive tubes from presumptive test were streaked on to selective agars such as Eosine Methylene Blue agar (EMB), Manitol salt agar, Bile esilin agar, TCBS agar, Mac Conkey agar and Salmonella – Shigella agar (SSA). Typical colonies in each agar were selected for further studies (Benson 2002).
Completed Test

Selected typical colonies were inoculated into lactose broth containing Durham’s tube once again and incubated at 37°C for 24h. Each positive tube was streaked on Trypticase Soy agar (TSA) plates for identification test such as carbohydrate fermentation, catalase test, gelatin hydrolysis, IMViC test and urease test (Benson 2002).

Identification of Bacterial Species

For identification of bacteria staining, colony characteristics, cultural characteristics, biochemical tests and characteristics of bacteria were used. In staining of bacteria Gram staining, Endospore staining, Capsule staining and Motility test were done. In order to study the morphology of bacteria, cells were heat killed and fixed on the slide. The fixed bacteria were stained and observed for size, shape, arrangement, spore formation and capsulation etc. Hanging drop method was performed to study motility of bacteria. The colony characteristics such as size, shape, margin and elevation were observed on nutrient agar medium.

*Escherichia coli (E.coli)*

It is a gram negative rod. It forms circular, low convex mucoid, opaque colonies with entire marginal growth on nutrient agar. Green metallic sheen colonies were observed on EMB agar. *E.coli* is the causal agent of gastroenteritis, urinary tract infections, and neonatal meningitis.

*Staphylococcus aureus (S.aureus)*

It is a gram positive coccus, non-spore forming and non-motile bacteria. It forms circular, low convex with entire margin, smooth, medium opaque colony on nutrient agar. It forms yellow coloured colonies on mannitol salt agar. *S.aureus*
incidence ranges from skin, soft tissue, respiratory, bone, joint, endovascular to wound infections. It causes a range of illnesses, from minor skin infections, such as pimples, impetigo, boils (furuncles), cellulitis folliculitis, carbuncles, scalded skin syndrome, and abscesses, to life-threatening diseases such as pneumonia, meningitis, osteomyelitis, endocarditis, toxic shock syndrome (TSS), bacteremia, and sepsis. It is still one of the five most common causes of nosocomial infections and is often the cause of postsurgical wound infections.

**Group D Streptococcus**

It is a gram positive coccus. It forms thin, even growth on nutrient agar. Black (or) Brown coloured colonies were observed on bile esulin agar. **Group D Streptococcus** causes urinary tract infections, meningitis, neonatal sepsis, spontaneous bacterial peritonitis, septic arthritis, and vertebral osteomyelitis diseases.

**Vibrio cholerae: (V.cholerae)**

It is a gram negative curved rod. It forms abundant, thick, mucous white coloured colonies on nutrient agar and yellow coloured colonies on TCBS agar. **Vibrio cholerae** is responsible for the occurrence of cholera.

**Vibrio parahaemolytics: (V.parahaemolyticus)**

It is a gram negative curved rod. It forms abundant, thick, mucous white coloured colonies on nutrient agar and green coloured colonies on TCBS agar. **V. parahaemolytics** is responsible for gastrointestinal illness in humans.
**Klebsiella pneumoniae: (K.pneumoniae)**

It is a gram negative rod. It forms slimy, white somewhat translucent, raised growth on nutrient agar and dark pink coloured colonies on mac - conkey agar. *Klebsiella pneumonia* is responsible for pneumonia, thrombophlebitis, urinary tract infection (UTI), cholecystitis, diarrohea, upper respiratory tract infection, wound infection, osteomyelitis, meningitis, and bacteremia and septicemia.

**Salmonella typhi: (S.typhi)**

It is a gram negative rod. It forms thin even grayish growth on nutrient agar and dark green colonies on SS agar. *Salmonella typhi* causes typhoid.

**Shigella dysenteriae: (S.dysenteriae)**

It is a gram negative rod. It forms grayish growth on nutrient agar and colourless colonies on SS agar. *Shigella dysenteriae* is the bacillary dysentery causing bacterium.
Results

Based on the sanitary survey of the sampling station of riverine system, the MPN index of total coliform and faecal coliform of bacteria of Station 1 (Banjari) to Station 10 (Dinapur) were analyzed. The experimental results, figures of the present study are summarized in the tables 70 – 73 and Fig. 68 – 83. The Colonies were formed in different media given in table 74. Biochemical tests for Bacteria in water samples are illustrated in table 75. Distribution of bacterial pathogens isolated from water samples in river Sone represented in table 76.

Among the overall findings the bacterial samples of different stations clearly indicates that the total coliform count was higher than that of the faecal coliform. The highest total coliform observed at Banjari (S1) (280/100ml) in the month of May 2010 and the lowest total coliform was noticed at Banjari (S1) (40/100ml) in the month of September and October 2008. The seasonal variation of total coliform count was given in the table 45 and 46. At Tilauthu (S2) the MPN value was varied between 50 - 240/100ml. The MPN value was high during July 2009 and low during October 2008. The MPN of water samples obtained from Indrapuri (S3) varied from 34/100ml (September 2008) to 500/100ml (July 2009). At Sikaria (S4) the MPN value of water samples ranged between 80 - 500/100ml. The lowest value was observed in October 2008, March 2009 and higher during August 2008.

The MPN of the water samples collected from Aurangabad (S5) varied from 40 - 500/100ml. The lowest value was observed in October 2008 and the highest MPN value was observed during August 2008 and April 2009. The MPN value obtained from Dehri (S6) showed a maximum of 500/100ml during August 2009 and minimum of 40/100ml during August 2008 and April 2009. The MPN of the water
samples ranged between 60 - 500/100ml at Daudnagar (S7). The lowest MPN value recorded during August 2008 and the highest value recorded during September 2008 and June 2009.

At Bikramganj (S8) the MPN of the water samples varied from 70 - 350/100ml. The MPN value was high during August 2009 and low during August and September 2008. The MPN of water sample collected from Jehanbad (S9) varied from 70 - 500/100ml. The lowest MPN value obtained during April 2010. The highest MPN value obtained during April 2009. At Dinapur (S10) the MPN value varied from 50 - 240/100ml. The lowest MPN value observed during September 2008 and highest MPN value obtained during April and May 2009. The population of bacteria varied between station and month. Similarly showed seasonal variation (Figures 68 and 77). The highest coliform was noticed at Aurangabad (S5) in rainy (400/100ml) and the lowest coliform was observed at Banjari (S1) in rainy season (45/100ml) (Table 70).

**MPN Index of Water Samples for Faecal Coliform**

The highest faecal coliform count was observed at Banjari (S1) (110/100ml) in the month of April and July 2009 and the lowest faecal coliform count 17/100ml was noticed in the month of October 2008 (Table 71). The faecal coliform count was varied from 22/100ml to 140/100ml at Tilauthu (S2). The lowest MPN value observed in January 2010 and highest value was during July 2009. At Indrapuri (S3) the faecal coliform count varied between 21 - 280/100ml. The highest count recorded during August 2008 and July 2009 and the lowest count recorded during October 2008. The MPN of water samples obtained from Sikaria (S4) varied form 27 - 280/100ml. The lowest faecal coliform count was registered during October 2009 and March 2010 and the highest faecal coliform count was registered during July 2009. The MPN value of
water samples ranged between 17/100ml to 270/100ml. The lowest faecal coliform count obtained during October 2008 and December 2008 and highest faecal coliform count obtained during August 2008 at Aurangabad (S₅).

The faecal coliform obtained from the water sample collected from the Dehri (S₆) varied from 22 - 280/100ml. The lowest coliform count was registered during the period of October 2009 and the highest coliform count was registered during August and September 2009. Similarly at Daudnagar (S₇) the minimum faecal coliform count 22/100ml during January 2009 and February 2010 and the maximum coliform count 280/100ml during September 2008 and March 2010 were registered during the period of investigation.

At Bikramganj (S₈) the faecal coliform count ranges between 17 - 220/100ml. The lowest MPN value recorded during February 2009. The highest MPN value recorded during October 2008 and February 2009. Whereas at Jehanabad (S₉) the lowest faecal coliforms count 23/100ml obtained during April 2010. Moreover, at Dinapur (S₁₀) the faecal coliform 140/100ml observed during April 2009. The lowest faecal coliform count 22/100ml during the periods of September 2008, November, December 2009 and March 2010. Similarly the faecal coliform bacteria showed a seasonal trend (Figures 54 and 69). The data interpreted in the table no 48 the highest faecal coliform was seen at Aurangabad (S₅) and Dehri (S₆) (190/100ml) during rainy season in the year 2008 and 2009 where as the lowest faecal coliform was noticed at Banjari (S₁) (21/100ml) during retreat season in 2009. In overall observation the total coliform and faecal coliform were highly fluctuated in all the stations (Table 70 - 77). In table 50 shows that colonies were formed in different media, EMP agar plate showed green metallic sheen indicating the presence of *E.coli*. It founds in all the
samples from $S_1$ to $S_{10}$ followed by Mannitol salt agar showed yellow colonies indicating the presence of $S. aurerus$ in $S_1, S_3, S_4, S_6, S_7$ and $S_{10}$.

Bile escelin agar showed brown colonies indicating the presence of Group $D$ Streptococcus in all the samples except the sample $S_6$. Whereas TCBS agar showed yellow colonies indicating the presence of $V. cholerae$. It founds in $S_2, S_4, S_5$ and $S_9$. Simultaneously the TCBS agar also showed green colonies indicating the presence of $V. paraheamolytics$ in $S_4$ to $S_{10}$.

The Mac conkey medium showed dark pink colonies indicating the presence of $K. pneumoniae$ in Station 1 to Station 9 ($S_1$ - $S_9$). Moreover, SSA agar medium found dark green colonies showed a presence of $S. typhi$ in $S_1, S_3, S_5, S_6, S_7, S_9$ and $S_{10}$. At the same time SSA agar medium yielded colourless colonies indicating the presence of $S. dysenteriae$ in $S_1, S_2, S_4, S_5$ and $S_8$. The complete coliforms test showed a positive test for all the water samples.

The biochemical characteristics of the isolates obtained from these water samples are shown in Table 51. The identified isolates includes $Escherichia coli$, $Staphylococcus aureus$, Group $D$ Streptococcus, $Vibrio cholera$, $Vibrio parahaemolytics$, $Klebsiella pneumonia$, $Salmonella paratyphi$ and $Shigella dysenteriae$. The above results concluded that, each group of bacteria are harmful to human beings, plants and animals.
Figure - 68: Total Coliform Fluctuation in Different Seasons in 2008 – 2010

Figure - 69: Faecal Coliform Fluctuation in Different Seasons in 2008 – 2010

Figure - 70: Total and Faecal Coliform Population in Different Stations during Rainy Season in 2008
Figure - 71: Total and Faecal Coliform Population in Different Stations during Retreat Season in 2008

Figure - 72: Total and Faecal Coliform Population in Different Stations during Winter Season in 2008-2009

Figure - 73: Total and Faecal Coliform Population in Different Stations during Summer Season in 2009
Figure - 74: Total and Faecal Coliform Population in Different Stations during Rainy Season in -2009

![Graph showing total and faecal coliform population in different stations during rainy season.]

Figure - 75: Total and Faecal Coliform Population in Different Stations during Retreat Season in -2009

![Graph showing total and faecal coliform population in different stations during retreat season.]

Figure - 76: Total and Faecal Coliform Population in Different Stations during Winter Season in 2009 2010

![Graph showing total and faecal coliform population in different stations during winter season.]

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Figure - 77: Total and Faecal Coliform Population in Different Stations during Summer Season in 2009 & 2010

Figure - 78: Monthly Variation of Total coliforms Population in 2008

Figure - 79: Monthly Variation of Total Coliforms Population in 2009
Figure - 80: Monthly Variation of Total Coliforms Population in 2010

Figure - 81: Monthly Variation of Faecal Coliforms Population in 2008

Figure - 82: Monthly Variation of Faecal Coliforms Population in 2009
Figure - 83: Monthly Variation of Total Coliforms Population in 2010

Plate 25: Five tube technique (MPN) of water samples during Analysis
Plate 26: Growth of different Bacterial species isolated from the different water samples (S₁ – S₁₀)

26 (a) - Growth of E.coli on EMB agar samples (S₁ – S₁₀)
26(b) - *Staphylococcus aureus* on Mannitol Salt agar
26(c) – Group D Streptococcus on Bile Escelin Agar
26(d) - *Vibrio cholrae* on TCBS agar
26 (e) - Vibrio paraheamalytics on TCBS agar
26 (f) - Klebsilla pneumonia on Mac – conkey
26( g) - *Salmonella typhi* on SSA agar
26(h) - *Shigella dysenteriae* on SSA agar
Discussion

The bacteriological evaluation carried out all the water samples collected from the sampling station and the result are presented in (Table 70 – 73). The MPN of total coliform recorded at station 1 to 10 (S₁ – S₁₀) appeared to reflect the intensity and type of human activities in the surrounding areas. Coliform bacteria multiply in enriched waters (Sharma and Bharadwaj, 2000). Hence a high count of bacterial population was seen at Banjari (S₁) (280/100ml) in May 2010. At Tilauthu (S₂) (240/100ml) in July 2009, In July 2009 (500/100ml) at Indrapuri (S₃). At Sikaria (S₄) and Aurangabad (S₅) (500/100ml) in August 2008. In August 2009 (500/100ml) at Dehri (S₆). In September 2008 and June 2009 (500/100ml) at Daudnagar (S₇). The MPN value in August 2008 (250/100ml) at Bikramganj (S₈). At Jehanabad (S₉) (500/100ml) in April 2009. In April and May 2009 at Dinapur (S₁₀) (240/100ml). More over during rainy season the highest coliform 400/100ml was noticed at Banjari (S₁).

The results reflect poor hygienic practices by surrounding villagers and the possible sources of contamination by both man and other animals. Most of the people discharge their waste into river directly rather than poor people living near the river discharge their shit at river bank (Srivastava et al., 2011). There was a positive correlation seen between MPN total coliforms, faecal coliforms and some abiotic factors like chlorides, Temperature, BOD and COD. At Banjari (S₁) total and faecal coliform with Temperature, BOD and COD shows positive correlation (Table 52) where as at Tilauthu (S₂) total and faecal coliform only with COD shows positive correlation (Table 53). Similarly certain abiotic factors show positive correlation with total and faecal coliform in the sampling station S₃ to S₁₀ (Table 54 - 61).
The MPN water sample the highest faecal coliform was observed at Banjari (S₁) (110/100ml) in April and July 2009. At Tilauthu (S₂) (140/100ml) in July 2009. In August 2008 and July 2009 at Indrapuri (S₃) (280/100ml). At Sikaria (S₄) (280/100ml) in July 2009. Followed by at Aurangabad (S₅) (270/100ml) in August 2008. The highest faecal coliform yielded at Dehri (S₆) (280/100ml) in August and September 2009. Similarly at Daudnagar (S₇) (280/100ml) in September 2008 and March 2010. Whereas at Bikramganj (S₈) (220/100ml) in October 2008 and February 2009. At Jehanabad (S₉) (280/100ml) in April 2009, similarly in April 2009 at station Dinapur (S₁₀) (140/100ml). Like total coliform the faecal coliform bacteria also showed a seasonal trend (Fig 68 & 69). The highest faecal coliform was seen at Aurangabad (S₅) and Dehri (S₆) (190/100ml) during rainy season in the year 2008 and 2009.

The above mentioned results concluded that the faecal coliform density was high in all the sampling sites. This result reveals that the faecal pollution from failing septic systems, sewage, agricultural runoff and wild animals affects human and environmental health (Lipp et al., 2002). Most of the stations of River Sone receive untreated sewage and septic tank overflows. According to Krishnamoorthy and Natarajan (2013) river water was grossly polluted by total and faecal coliform organisms are mainly attributed to the high amount of raw sewage.

According to Gholami et al., (2010) the main cause of deterioration in water quality of River Cauvery in Krishna Raja Sagar, in Karnataka was due to the lack of proper sanitation, unprotected river sites and high anthropogenic activities. The same activities observed in the present study. The banks of River Sone used as open toilet for most of the villages alongside the rivers. There were no proper toilet facilities in these villages and hence they resort to use river banks for defecation.
Donderski et al., (2002) the unhygienic conditions of water associated with drinking and recreation may result in human infections and diseases through the ingestion of pathogenic microorganisms which are indicated by the presence of indicator bacteria. Analysis of Bacterial pathogen from various sampling station are presented in the table 49. The *Escherichia coli* (*E.coli*) present in all the sampling stations from 1 to 10. *E. coli* indicate an increased likelihood of pathogens being present. *Escherichia coli* are the most widely adopted indicator of faecal pollution. Outbreaks of these diseases can occur as a result of, drinking water polluted by a combination of different wastewater, eating contaminated fish, or indulging in recreational activities in polluted water bodies containing water borne pathogen such as *E. coli* cause urinary tract infection and diarrhea and Bacillus can cause the anthrax (Ashok Kumar et al., 2010).

Followed by *Staphylococcus aureus* (*S.aureus*) present in *S*₁, *S*₃, *S*₄, *S*₆, *S*₇ and *S*₁₀. It is the most common cause of staphylococcal infections. It can cause a range of illnesses from minor skin infections, such as pimples, impetigo, boils, cellulitis folliculitis, furuncles, carbuncles, scalded skin syndrome and abscesses, to life-threatening diseases such as pneumonia, meningitis, osteomyelitis, endocarditis, toxic shock syndrome, and septicemia. Its incidence is from skin, soft tissue, respiratory, bone, joint, endovascular to wound infections (Fine et al., 1996).

*Group D Streptococcus* most of the sampling stations except Dehri (*S*₆). *Vibrio cholerae*: (*V.cholerae*) found in *S*₂, *S*₄, *S*₅ and *S*₉. *V.cholerae* is responsible for the occurrence of cholera (Table 76). The occurrence of *V. cholerae* in rivers is sometimes reported but it is usually may be short-lived. Colwell et al., (2000), interpreted that there was a possibility that *Vibrio spp.* can exist as bacteria in rivers and other aquatic environments. It proliferates only when it gets the right
environmental conditions, and it is possible that, through this polluted water and aquatic foods, people may become infected (Wilson et al., 1984).

Whereas *Vibrio parahaemolyticus*: *(V.parahaemolyticus)* present in S₄, S₅, S₆, S₇, S₈, S₉ and S₁₀. Among ten, seven samples were showed positive results for *V. parahaemolyticus* which indicates the harmfulness of this drinking water in present and future. *Vibrio parahaemolyticus* causes watery diarrhea often with abdominal cramping, nausea, vomiting, fever and chills. Severe disease is occurs more commonly in persons with weakened immune systems. *V. parahaemolyticus* can also cause an infection of the skin when an open wound is exposed. *Klebsiella pneumoniae*: *(K.pneumoniae)* present in S₁, S₂, S₃, S₆, S₈ and S₉. It responsible for pneumonia, thrombophlebitis, urinary tract infection (UTI), cholecystitis, diarrohea, upper respiratory tract infection, wound infection, osteomyelitis, meningitis, and bacteremia and septicemia (Laxmi Soumya et al., 2015)

Similarly *Salmonella typhi*: *(S.typhi)* present in S₁, S₃, S₅, S₆, S₇, S₉ and S₁₀. *S. typhi* causes typhoid fever. The small count of salmonella should be alarming because they can easily spread under favorable conditions and make a serious source of environmental pollution (Tymczyna 2000). Moreover, *Shigella dysenteriae*: *(S.dysenteriae)* present in S₁, S₂, S₄, S₅ and S₈. It is the bacillary dysentery causing bacterium. These results were clearly alarming the river directly dispose off their domestic sewages, human and animal excreta etc.

The overall significant of the microbiological analysis of the water samples from the riverine Sone from S₁ to S₁₀ shown that, Most of the sample of river water have higher total coliforms, because of contaminant sources from the fact that, people living in the river areas directly dispose off their domestic sewage, human and animal excreta into the water body. From the bacteriological points of view, the water sample
was not suitable for drinking purpose without adequate treatment and it is suggested that, there should be proper treatment of sewage effluents to minimize the pollutants load in water quality of river Sone and some immediate measures have to be taken to maintain the water quality.

**Incidence of water borne diseases**

In table no 86 - 94, the data found that, an overall percentage (%) of infection due to the water born infected patient’s details from three different hospitals (Rothas Govt. Hospital, Aurangabad Govt. Hospital and Jehanabad Govt. Hospital). Reason while our sampling stations (S₁ to S₁₀) riverine system very closely connected to aforesaid hospitals. The ultimate aim of the investigation to find out whether the microbiological data resembles the actual results yielded in the particular station coherently reflects the same response in the hospital patient’s history.

The study area covers 3 districts such as Rohtas, Aurangabad and Jehanabad. Three years data 2008 - 2010 were collected from aforesaid districts. This data are taken from the Annual Report of Government Hospitals. The above tabular data shows the number of patients affected by water borne and water based diseases such as Acute Diarrhoeal Disease (including gastroenteritis), Bacillary Dysentery, Enteric fever, Shigellosis, Cholera, Typhoid, Jaundice, Malaria and Skin diseases. So it should be understood that the table shows the number of patients’ aforesaid diseases treated by the Government Hospital. The table also shows the number of patients affected by the diseases monthly wise. So we can get the following information from the tabular data.

Table 86 - 88 and Figure 84 - 86 shows monthly wise the number of patients affected by water borne and water based diseases in Rohtas district of Bihar in the
year 2008 - 2010. The following stations comes under the Rothas District such as Station 1 - Banjari, Station 2 - Tilouthu, Station 3 - Indrapuri, Station 4 - Sikaria, Station 6 - Dehri and Station 8 - Bikramganj. According to the report the water borne and water based diseases were very high in the months of July, August and September which is season in Rohtas District of Bihar. Most number of people was affected by Acute Diarrhoeal Disease with 38% in 2008 and 28 % in 2009 and 2010 followed by Bacillary Dysentery with 36% in 2008, 29% in 2009 and 36% in 2010. Moreover, 5% enteric fever case reported in 2008, in 2009 with 4% and in 2010 with 2% cases were registered.

Similarly in the case of shigellosis recorded 4% in 2008, 3% in 2009 & 2010. It is remarkable to learn from the table that no cholera case is registered throughout the year 2008 and 2010. But unfortunately only one case reported during August - 2009. More number of typhoid case 16% registered in 2008 followed by 9 % in 2009 and 8% in 2010. Likewise in the case of Jaundice 12% in 2008, in 7% in 2009 and 5% were reported in 2010. Malaria has affected 25% of the patients in 2008, 20% in 2009 and 15 % in 2010. Very less number of people were affected by skin diseases i.e., 3 % in 2008&2009 and 2% in 2010. Table 79, 80 and 81 is the tabular data showing the season wise details of the water borne and water based diseases in Rohtas District of Bihar in 2008. So it is understood that these diseases are vigorous in rainy season.

Moreover, Table 89 - 91 and Figures 84 - 89 reveals monthly wise the number of patients affected by water borne and water based diseases in Aurangabad district of Bihar in the year 2008 - 2010. The following station comes under the Aurangabad district such as Station 5 – Aurangabad and Station 7 - Daudnagar. The maximum number of people was affected by Acute Diarrhoeal Disease with 25% in 2008 and 30 % in 2009 and 26% in 2010 followed by Bacillary Dysentery with 29% in 2008, in
2009 and in 2010. Moreover, 4% enteric fever case reported in 2008 & in 2009, and in 2010 with 3% cases were registered. Similarly in the case of shigellosis recorded 5% in 2008, 4% in 2009 and 2010. It is interesting to learn from the table that no cholera case is registered throughout the year 2008 and 2010. More number of typhoid case 6% registered in 2008 followed by 8% in 2009 & 2010. Likewise in the case of Jaundice 8% in 2008, in 4% in 2009 and 8% were reported in 2010. Malaria has affected 19% of the patients in 2008, 18% in 2009 and 19% in 2010. Very negligible number of people were affected by skin diseases i.e., 4% in 2008, 3% in 2009 and 2% in 2010. Table 82, 83 and 84 is the tabular data showing the season wise details of the water borne and water based diseases in Aurangabad District of Bihar in 2008. So it is understood that these diseases affected maximum during rainy season. So finally the annual report from Aurangabad district Government Hospital 2008 - 2010 prove that these diseases are very much endangerly targeting the people in the rainy season.

Table 92 - 94 and Figures 90 - 92 indicated monthly wise the number of patients affected by water borne and water based diseases in Jehanabad district of Bihar in the year 2008 - 2010. The following station comes under the Jehanabad District a Station 9 - Jehanabad and Station 10 in Dinapur. Actually Dinapur comes under the Patna District but according to the hospital report the people of Dinapur using the Aurangabad Hospital due to easy access. Maximum number of people was affected by Acute Diarrhoeal Disease with 24% in 2008 and 27 % in 2009 and 25% in 2010 followed by Bacillary Dysentery with 25% in 2008, 27% in 2009 and 22% in 2010. Moreover, 4% enteric fever case reported in 2008, 3% in 2009 and in 2010 with 2% cases were registered.
Similarly in the case of shigellosis recorded 2% in 2008, 3% in 2009 and 9% in 2010. It should be noted from the table (Table 92 -94) that only one cholera case was registered throughout the year 2008 and 2010. More number of typhoid case 15% registered in 2008 followed by 12 % in 2009 and 7% 2010. Likewise in the case of Jaundice 5% in 2008, in 7% in 2009 and 8% were reported in 2010. Malaria was affected 20% of the patients in 2008, 21% in 2009 and 25 % in 2010. Very least number of people were affected by skin diseases i.e., 5 % in 2008, 2% in 2009 and 2% in 2010. Table 85, 86 and 87 is the tabular data shows the season wise details of the water borne and water based diseases in Jehanabad District of Bihar in 2008. So it is understood that these diseases affected maximum during rainy season. So overall the annual report from Jehanabad district Government Hospital 2008 - 2010 confirmed that these diseases are effectively targeted the people in the rainy season.
Figure 84 - Season Wise Waterborne and Water Based Diseases on Rohtas District in 2008

Figure 85 - Season Wise Waterborne and Water Based Diseases on Rohtas District in 2009

Figure 86 - Season Wise Waterborne and Water Based Diseases on Rohtas District in 2010
Figure 87 - Season Wise Waterborne and Water Based Diseases on Aurangabad District in 2008

Figure 88 - Season Wise Waterborne and Water Based Diseases on Aurangabad District in 2009

Figure 89 - Season Wise Waterborne and Water Based Diseases on Aurangabad District in 2010
Figure 90 - Season Wise Waterborne and Water Based Diseases on Jehanabad District in 2008

Figure 91 - Season Wise Waterborne and Water Based Diseases on Jehanabad District in 2009

Figure 92 - Season Wise Waterborne and Water Based Diseases on Jehanabad District in 2010
Figure 93 – The overall study period the percentage of water borne and water based diseases on Rohtas District

Figure 94 - The overall study period the percentage of water borne and water based diseases on Aurangabad District

Figure 95- The overall study period the percentage of water borne and water based diseases on Jehanabad District
Fig. 9.6(a) A graph of Acute Diarrhoea against Mean TC MPN/100ml for the year 2008-2010

Fig. 9.6(b) A graph of Acute Diarrhoea against Mean FC MPN/100ml for the year 2008-2010

Fig. 9.6(c) A graph of Acute Diarrhoea against Mean TC MPN/100ml for the year 2008-2010

Fig. 9.6(d) A graph of Acute Diarrhoea against Mean FC MPN/100ml for the year 2008-2010

Fig. 9.6(e) A graph of Acute Diarrhoea against Mean FC MPN/100ml for the year 2008-2010

Fig. 9.6(f) A graph of Acute Diarrhoea against Mean FC MPN/100ml for the year 2008-2010

Fig. 9.6 Shows the scatter plots between TC and FC MPN/100ml and Acute Diarrhoea
Fig 97. (a) A graph of Bacillary Dysentry against Mean TC MPN/100ml for the Year 2008-2010

Fig 97. (b) A graph of Bacillary Dysentry against Mean TC MPN/100ml for the Year 2008-2010

Fig 97. (c) A graph of Bacillary Dysentry against Mean TC MPN/100ml for the Year 2008-2010

Fig 97. (d) A graph of Bacillary Dysentry against Mean TC MPN/100ml for the Year 2008-2010

Fig 97. Shows the scatter plots between TC and FC MPN/100ml and Bacillary Dysentry

Fig 98. (a) A graph of Bacillary Dysentry against Mean TC MPN/100ml for the Year 2008-2010

Fig 98. (b) A graph of Bacillary Dysentry against Mean TC MPN/100ml for the Year 2008-2010
Fig. 98(c) A graph of Shigellosis against Mean TC MPN/100ml for the Year 2008-2010

Fig. 98(d) A graph of Shigellosis against Mean FC MPN/100ml for the Year 2008-2010

Fig. 98(e) A graph of Shigellosis against Mean FC MPN/100ml for the Year 2008-2010

Fig. 98 Shows the scatter plots between TC and FC MPN/100ml and Shigellosis

Fig. 99(a) A graph of Typhoid against Mean TC MPN/100ml for the Year 2008-2010

Fig. 99(b) A graph of Typhoid against Mean FC MPN/100ml for the Year 2008-2010
Fig. 99 (c) A graph of Typhoid against Mean TC MPN/100ml for the Year 2008-2010

Fig. 99 (d) A graph of Typhoid against Mean FC MPN/100ml for the Year 2008-2010

Fig. 99 Shows the scatter plots between TC and FC MPN/100 ml and Typhoid

Fig. 100 (a) A graph of Acute Diarrhoea against Mean TC MPN/100ml for the Year 2008-2010

Fig. 100 (b) A graph of Acute Diarrhoea against Mean FC MPN/100ml for the Year 2008-2010

Fig. 100 (c) A graph of Acute Diarrhoea against Mean TC MPN/100ml for the Year 2008-2010

Fig. 100 (d) A graph of Acute Diarrhoea against Mean FC MPN/100ml for the Year 2008-2010

Fig. 100 Shows the scatter plots between TC and FC MPN/100ml and Acute Diarrhoea
Fig. 101(a). A graph of Bacillary Dysentery against Mean TC MPN/100ml for the Year 2008-2010

Fig. 101(b). A graph of Bacillary Dysentery against Mean FC MPN/100ml for the Year 2008-2010

Fig. 101(c). A graph of Bacillary Dysentery against Mean TC MPN/100ml for the Year 2008-2010

Fig. 101(d). A graph of Bacillary Dysentery against Mean FC MPN/100ml for the Year 2008-2010

Fig 101. Shows the scatter plots between TC and FC MPN/100ml and Bacillary Dysentery

Fig. 102(a) A graph of Shigellosis against Mean TC MPN/100ml for the Year 2008-2010

Fig. 102(b) A graph of Shigellosis against Mean FC MPN/100ml for the Year 2008-2010
Fig. 102 (a) A graph of Shigellosis against Mean TC MPN/100ml for the Year 2008-2010

Fig. 102. Shows the scatter plots between TC and FC MPN/100ml and Shigellosis

Fig. 103 (a) A graph of Typhoid against Mean FC MPN/100ml for the Year 2008-2010

Fig. 103 (b) A graph of Typhoid against Mean TC MPN/100ml for the Year 2008-2010

Fig. 103. Shows the scatter plots between TC and FC MPN/100ml and Typhoid
Correlation analysis (R\(^2\) and r statistics) for Acute Diarrhoea

In order to achieve this, the data were analyzed using SPSS version 20. These data include: the seasonal variation of TC and FC of the MPN/100 ml concentrations of the river Sone Table 72 & 73 and a three year statistical data of the incidence of water borne diseases in season wise collected from the three main hospitals in Sone river basin (Table 95 – 103).

The deterministic model (R\(^2\)) and the correlation coefficients (r) between the variables (Acute Diarrhoea and MPN/100ml) were calculated and the results are shown in Tables 104, 105 and 106 respectively. The values of R\(^2\) (Table 105 and 106) helps to interpret the relationships exiting between variables in terms of variations. The R\(^2\) value from Rothas Govt Hospital in the year 2008 – 2010 at Indrapuri (S\(_3\)) had 0.878. The R\(^2\) value indicate 87.85% of the changes in the acute diarrhoea and MPN/100ml. the closer R\(^2\) is to 1, then there is an indication that the data points to be found close to the least square line. This can be seen in Fig. 96. This means that the linear regression analysis performed to estimate the R\(^2\) describe the variation in the data well for Rothas Govt Hospital. Followed by Sikaria (S\(_4\)), Tilouthu (S\(_2\)), Dehri (S\(_6\)) the R\(^2\) values had 0.658, 0.592, 0.501 respectively. These values were partially closer to 1 therefore the acute diarrhoea and MPN/100ml not completely controlled by the data from Rothas Govt Hospital. The similar R\(^2\) values observed in the Aurangabad Govt Hospital in the case of acute diarrhoea and MPN/100ml at station Aurangabad (S\(_5\)) and Daudnagar (S\(_7\)) in 2008 and 2010.

The deterministic the correlation coefficients (r) between the variables acute diarrhoea and MPN/100ml were calculated and the results are shown in Table 104. According to the result the following stations Tilouthu (S\(_2\)), Indrapuri (S\(_3\)), Sikaria
(S₄), Aurangabad (S₅), Dehri (S₆) and Daud nagar (S₇) were positively correlated with acute diarrhoea and MPN/100ml during the study period (Table 104).

**The correlation coefficients for Bacillary dysentery incidence**

From the graphs (Fig. 97) indicated that there was linear correlation between Bacillary dysentery and MPN/100ml. Tables 104, 105 and 106 shows the values of the correlation (r) and the coefficients determination of \( R^2 \) respectively. The correlation coefficients (Table 104) for Rothas Govt. Hospital are 0.804 at Indrapuri (S₃). The \( R^2 \) value indicates 80.4% of the changes in the bacillary dysentery and MPN/100ml. To point out that, the linear regression analysis performed to estimate the \( R^2 \) describe the variation in the data was well for Rothas Govt Hospital. At the same time the \( R^2 \) value of Tilothu (S₂) and Indrapuri (S₃) had yielded 0.255, 0.551 respectively. It reveals that the percentage of bacillary dysentery and MPN/100ml as not high as depend on Rothas Govt Hospital.

Moreover, the Aurangabad Govt Hospital the \( R^2 \) value had 0.722 at the sampling station of Aurangabad (S₅). This value was favor for the data of Aurangabad Govt. Hospital, when compared with Daud nagar (S₇) had 0.657 indicate only partially favor for the Aurangabad Govt Hospital data. According to the correlation coefficient analyses the Bacillary dysentery and MPN/100ml were positively correlated with stations Tilouthu (S₂), Indrapuri (S₃), Sikaria (S₄), Aurangabad (S₅), and Daud nagar (S₇) which signify that the bacillary dysentery and MPN/100ml were profound with Rothas Govt Hospital (Table 104).
The correlation coefficients for Shigellosis incidence

The correlation coefficients (Table 105) for Rothas Govt. Hospital are 0.777 ($S_3$), 0.650 ($S_4$) and 0.804 ($S_5$). The $R^2$ value indicates that changes in the Shigellosis and MPN/100ml. It reveals that the linear regression analysis performed to estimate the $R^2$ describe the variation in the data was significant for Rothas Govt. Hospital (Fig 98). Followed by Aurangabad Govt. Hospital had 0.527 and 0.502 at Aurangabad ($S_5$) and Daud nagar ($S_7$) respectively. The $R^2$ value indicate that, it was not completely controlled by the Aurangabad Govt. Hospital during 2008 -2010. The analyses of correlation coefficient the Shigellosis and MPN/100ml were positively correlated with stations Indrapuri ($S_3$), Sikaria ($S_4$), Aurangabad ($S_5$) and Daud nagar ($S_7$) which note that the Shigellosis and MPN/100ml profound with Rothas Govt. Hospital data (Table 104).

The correlation coefficients for Typhoid incidence

The table 105 shows that the $R^2$ value 0.966 at Indrapuri ($S_3$) and 0.858 at Sikaria ($S_4$). The $R^2$ value indicates 96.6 % and 85.8% changes in the Typhoid and MPN/100ml. It reveals that the linear regression analysis performed to estimate the $R^2$ describe the variation in the data was quiet well for Rothas Govt. Hospital in the year 2008 – 2010 (Fig 99). Nevertheless in the case of Aurangabad Govt. Hospital the $R^2$ value 0.499 and 0.588 at Aurangabad ($S_5$) and Daudnagar ($S_7$). The value was not favor to the Aurangabad Govt. Hospital.

The result of correlation coefficient the typhoid and MPN/100ml were positively correlated with stations Indrapuri ($S_3$), Sikaria ($S_4$), Aurangabad ($S_5$) and Daud nagar ($S_7$) which reveals that the Typhoid and MPN/100ml were partially control over the Rothas Govt. Hospital (Table 104). The station Banjari ($S_1$)
Bikramganj (S₈) and Dinapur (S₁₀) fails to yield any significant variation with MPN/100ml and water borne diseases form hospital.

In present investigation, the correlation coefficient (r) was used as a criterion to determine the strength between water polluted with coliform (MPN/100ml) and water borne and water based diseases such as acute diarrhoea, bacillary dysentery, shigellosis, typhoid. It was interested to refer that these diseases are shows abundant significantly relationship between MPN/100ml with hospital recorded cases. The correlation coefficient values obtained with the findings of Pielou (1998). He pointed out that “human and animal excreta waste contains disease-carrying organisms such as the bacterium Escherichia coli and pathogens that cause cholera, typhoid, diarrhea, dysentery, hepatitis A and cryptosporidiosis”. With this evidence in the case of acute diarrhoea, bacillary dysentery reported in Indrapuri, Sikaria, Tilouthu, Dehri, Aurangabad and Daudnagar.

These patients record were correlated significantly with MPN/100ml. The maximum number of cases acute diarrhoea reported in rainy months in the hospitals. Similarly by Pokhre et al., (1996) in Nepal showed maximum number of diarrhoel cases occurred in the rainy season (June to August). The diarrhoeal cases mainly due to consumption of contaminated water. In 2005 it was reported that 1.8 million people died from diarrheal diseases largely due to contaminated food and water (Newell et al., 2010). But the present investigation observed that contamination of water mainly due to the uncollected waste, which is often also mixed with human and animal excreta in the riverine system may be the main cause of the acute diarrhoea.

The shigellosis cases reported in the hospital data correlated with MPN/100ml at station Indrapuri, Sikaria, Dehri and Aurangabad. Disposal of human feces was one of the main cause for this shigellosis (Niyogi Swapan, 2005). The present study area
direct defecation and urination observed throughout the study period on the river bank. It was supported by Best et al., (1998) and Jain (2009).

Typhoid fever was the most serious form of enteric fever, with humans being the sole reservoir of the bacteria. Based on a recent survey, the global number of typhoid cases in 2000 exceeded 21,000,000, with more than 200,000 deaths (Crump 2004). The present study shows that stronger relationship (i.e significant at 1%) exist between Typhoid and MPN /100ml in Rothas Hospital in Indrapuri and Sikaria. Followed by Aurangabad Hospital in Aurangabad and Daud nagar shows 5% significant level between Typhoid and MPN /100ml. The principal means of acquiring the Salmonella typi was through ingestion of water contaminated with feces (faecal coliform). Also it can be acquired through bathing or any form of contact with this contaminated water. The disease caused one of the ways to ingesting contaminated water (Bhan, 2005).

In river Sone, almost everybody was exposed to typhoid fever infection because the entire river basin uses the river water for bathing and washing and sometime even drinking. Not only that but also all the restaurants in the city use this water for customers to drink, wash their hands before eating and also for washing the dishes. Therefore, in Sone, whether drink pure water or not; still remain at high risk of typhoid fever infection except avoid it by drinking, bathing with boiled water and not eating in a restaurant.

There are few water based diseases observed in the study area and also it was obtained from the Government hospital annual report. The water based diseases are such as Jaundice, malaria, and skin diseases. The Jaundice patients were observed on the river basin. It was confirmed by the data collected from the hospitals. The possible of spread of jaundice may be due to direct consumption of water from the river and
river water supplied by the municipality. Some time leakages in drinking water pipelines and overflowing drains in the area were observed. This result in entry of polluted water into the pipes when supply was closed (Rawat et al., 2012).

Malaria one of the dangerous water related disease even though disease caused by parasites but it spread through the bite of a mosquito. Permanent water and stagnant water, the mosquito species deposit their eggs directly on the water surface, and these may hatch in one to four days depending on temperature (Brandy and Holum, 1996). The present study area the water stagnation observed on the river basin due to broadness of river up to 3.5 km, siltation, and agricultural activities on the river bank. The water stagnation along with garbage dump is the cause of proliferate the mosquitoes. This disease was reported in all the study period in the hospital data. Very fewer number of skin disease reported and very least percentage of Chloera reported in the hospital data during 2008 - 2010. It may be attributed to the personal hygiene of the people.

**Conclusion**

The hospital data were showed clearly that the water borne diseases spread one of the ways through contamination of river sone. It was confirmed by microbial analysis through following tests such as MPN, presumptive test, confirmed test and completed test. Among the overall findings the bacterial samples of different stations clearly indicates that the total coliform count was higher than that of the faecal coliform. The maximum total coliform 500/100ml observed at Indrapuri (S3) in July 2009, Sikaria (S4) in August 2008, Aurangabad S5 in August 2008 and 2009, Dehri (S6) in August 2009, Daudnagar (S7) in September 2008 and Jehanabad (S9) in April (2009), Similarly the highest value of faecal coliform yielded 280/100ml from S1 to
such as Indrapuri ($S_3$) in August 2008 and July 2009, Sikaria ($S_4$) in August 2008, Dehri ($S_6$) in August and September 2009, Daudnagar ($S_7$) in September 2008, June 2009 and February 2010, Jehanabad ($S_9$) in April 2009. Based on seasonal variation, the highest coliform was noticed at Aurangabad ($S_5$) in rainy (400/100ml) at Aurangabad ($S_5$) in 2008, followed by the faecal coliform 206.66/100ml noticed during summer in 2009 at Jehanabad ($S_9$). The results reflect poor hygienic practices by surrounding villagers and the possible sources of contamination by both man and other animals.

Most of the people discharge their waste into river directly rather than poor people living near the river discharge their shit at river bank (Srivastava et al., 2011). The biochemical characteristics of the isolates obtained from these water samples includes *Escherichia coli*, *Staphylococcus aureus*, *Group D Streptococcus*, *Vibrio cholera*, *Vibrio parahaemolytics*, *Klebsiella pneumonia*, *Salmonella paratyphi* and *Shigella dysenteriae*, each group of isolated pathogens bacteria are harmful to human beings, plants and animals.

The hospital data found that, an overall percentage (%) of infection due to the water born infected patients details from three different hospitals (Rothas Govt. Hospital, Aurangabad Govt. Hospital and Jehanabad Govt. Hospital). The highest percentage (38%) of Acute diarrhoeal reported in the Rothas Govt. hospital. Followed by Aurangabad Govt. hospital the highest percentage of Acute diarrhoea 30% were reported. Jehanabad Govt. hospital the maximum of 27% acute diarrhoeal and Bacillary dysentery cases were reported. The overall hospital report prove that these water borne and water based diseases are very much vigorously targeting the people in the rainy season. The deterministic model ($R^2$) and the correlation coefficients ($r$)
between (Water borne and water based diseases and MPN/100ml) the Rothas Govt. Hospital had the following significant $R^2$ value 0.878, 0.804, 0.966, 0.858 respectively for acute diarrhoea; Bacillary Dysentery and Typhoid, Similarly 0.722, 0.804 exclusively for Bacillary Dysentery and Shigellosis were yielded for Aurangabad Govt. Hospital during the study period.

The peak of water borne and water based disease incidence was in the rainy season and also this is the opt time of the year when the river Sone was highly polluted, because the heavy rains wash any kind of waste into the river Sone. With just the naked eyes, one can easily see that the water was really polluted because of the amount of dirt in it. But really it carries pathogen which causes much water borne and water based diseases. Therefore the present study indicate that a deep exploration should be done to check if the water consumed by Sone river basin inhabitants is contaminated with entero-pathogens, or there are other factors, such as improper personal hygienic practices, wrong food habits and dirty surroundings in and out of their residence, responsible for enteric infections in this river basin.