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POPULATION DYNAMICS OF SALMONELLA IN TROPICAL RIVER KSHIPRA INDIA WITH RELATION TO WATER QUALITY

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ABSTRACT

Salmonella is one of the leading cause of intestinal illness all over world responsible for giving rise to typhoid and paratyphoid fever. Aim of the study is to detect the presence of various *Salmonella* strains with relation to physico-chemical characteristics and water quality of river Kshipra. Results obtained from the study are compared with recent trends of *Salmonella* occurrence in freshwater bodies across the world. Samples were collected from November 2013-October 2014 covering five different sites with high anthropogenic activities and human interferences. The occurrence of *Salmonella* was observed throughout the year total five species of Salmonella were isolated which includes *Salmonella typhi*, *Salmonella paratyphi A*, *Salmonella paratyphi B*, *Salmonella anatum and Salmonella typhimurium.* Maximum strains of Salmonella were reported during summer at Ramghat and minimum during winter season at Kshipra village study site respectively. *S. anatum* was found to be the most dominant species, where as *Salmonella paratyphi A* showed least count. One of the main reasons for contamination of water body is its sharing between humans and animals. High count of *Salmonella* is found to be directly correlated with high biological oxygen demand (BOD), chemical oxygen demand (COD) and lower dissolved oxygen (DO). Sites with higher Salmonella count show low water quality index and increased pollution load. From the present work, it is also clear that occurrence of *Salmonella* is directly proportional to anthropogenic activities of humans, discharge of sewage effluents and faecal contamination. Thus, this makes water unfit for drinking, bathing and other domestic use without proper treatment, this in turn poses a health risk to the communities which reside near-by and rely on water of this particular river for their domestic use. Public awareness, proper sanitary conditions and appropriate measures to control water pollution are required to provide lifeline to the dying river.

KEYWORDS: Bacteria, Pathogen, Water born disease, Water Pollution *Salmonella.*

INTRODUCTION

Water is one of the prime elements responsible for life on earth. The quality and quantity of available water has implications on the health status of a community. One third of the world population live in countries with some level of water stress and water scarcity is expected to increase in next few years due to increases in human population, per capita consumption and the resulting impacts of human activities on the environment (Asano *et al.* 2007). Good water sources are declining from day to day and this provokes the occurrence of water-borne diseases (Suresh and Smith, 2004). It is therefore critical to understand the relevance of natural and drinking water contribution to transmission of pathogenic microorganisms. Over 50,000 people die daily due to water born diseases (Herschy, 1999). Mortality of children under five year from water born diseases is estimated to be four million in developing countries (Warner, 1998). *Salmonella* are ubiquitous, intestinal bacteria which cause typhoid and paratyphoid fever in animals and humans. *Salmonella* infections are not only food born but also water born and are a cause of concern in terms of public health, especially in developing countries where waste water is directly discharged into lakes, ponds and rivers. Contaminated river water is the potential source of water born infections. Water born pathogens present a greater health risk to people using river water for drinking, bathing, irrigation, fishing and recreational activities (Liu *et al.*2006,Hellweger and Masopust, 2008). Drinking water and water used for domestic purpose should be properly treated in order to reduce the risk of water born diseases. In developing countries like India, there is a lack of proper sanitation and waste water disposal techniques which have become a major cause of increased level of water pollution. Hence, time has arrived when government, government aided agencies, local authorities and common man should take a step to understand importance of discharged, recycle and reuse of waste so that it can re-enter the ecosystem again. So the present study is conducted with an aim to detect the presence of different strains of *Salmonella*, its abundance, seasonal variation with relation to water quality. This would help to assess the risk of water born diseases like Salmonelosis, Typhoid, Paratyphoid and enteric fever which arise from use of contaminated water.

MATERIAL AND METHODS

Study area

River Kshipra originates from a hill of Vindhya range, one mile south of Kshipra village lying 12 km south-east of Indore city (M.P.).It flows approximately between latitude 22º49' and 23º50'N, longitude of 75º45' and 75º35'. River flows across Malwa plateau to join river Chambal which later joins Gangetic system. In the present study, five study sites with high ecological significance were selected on the banks of river Kshipra, they include Kshipra village, Triveni, Ramghat, Mangalnath and Mahidpur.

Water Sampling

Sampling was carried out monthly from November 2012 to October 2013 for isolation of microorganisms. Bacterial samples were collected aseptically using 500 *ml* sterile bottles and were kept in ice bucket, they were then transported to the base laboratory within 24 hours.

Isolation and Identification of *Salmonella*

The isolation of *Salmonella* strains was carried out using standard culture techniques (Oragui *et al.* 1993, APHA 2005). Buffered peptone water was used as a pre-enrichment medium prior to selective enrichment for resuscitation of cells that have been injured. 10 ml of water samples were added to 90 ml distilled water 50 ml of buffered peptone water and incubated at 37^0 C for 16-20 hrs. For selective enrichment, Selenite Cystine broth and Rappaport-Vassiliadis Soya (RVS) broth were used simultaneously. These two enrichment media (10 ml) were individually inoculated with 0.1 ml of pre-enrichment buffered peptone water culture and then incubated at 42^0C for 24-48 hrs. Obtained colonies were transferred to Dichlorocitrate Agar *(DCA) for* identification. Confirmation of species was done by applying various biochemical tests *(Alonso, et al. 1992).*

Analysis of Physicochemical Parameters

Sampling and analysis of various physicochemical parameters were done by using standard methods given in APHA (2005).

Water Born Diseases

Data of water born diseases was obtained by survey from major hospitals of Ujjain and Dewas city. A structural interview involving about 500 households randomly selected from all the four quarters in the city of Ujjain and Dewas. Respondents were required to furnish information on their sources of water for domestic use and the occurrence of water born diseases in their respective families.

RESULTS AND DISCUSSION

Total coliform and heterotrophic bacteria are used to evaluate hygienic status of a water body and presence of any coliform group in water indicates contact with sewage *(*Markosova and Jezek*, 1994).* Similarly, *Salmonella* is also regarded as an organism of faecal origin *(*Wheater *et al.1979)*. Higher count of *Salmonella* indicate faecal pollution of a water body and certify the fact that untreated waste, sewage, industrial effluents and agricultural runoff has entered in the water body. Fruits and vegetables washed or irrigated by these contaminated water and products consumed by inhabitants lead to various gastrointestinal disorders, typhoid, and Enteric fever.

Trends of *Salmonella* Occurrence in Kshipra river

The detailed microbial investigation of Kshipra river revealed the presence of *Salmonella* species in all collected samples (100% occurrence) higher than the portable limits. The evaluated samples contained *Salmonella* ranging from 0-18x10^3 CFU/100ml in Kshipra village, 6-61x10^3 CFU/100ml at Triveni, 17-91x10^3 CFU/100ml at Ramghat, 17-91x10^3 CFU/100ml at Mangalnath and 0-13x10^3 CFU/100ml at Mahidpur. The distribution trends of *Salmonella* at different sites were maximum at Ramghat (37.61%), followed by Mangalnath (26.27%), Triveni (21.56%), Mahidpur (10.97%) and Kshipra village (10.97%). *Salmonella* has been detected in different percentages by several authors in surface water ranging from 26.66% *Salmonella* in river water and 45% in pond water in Trivendrum district of Kerela India (Aruni and Prabakaran 2014), 62.9% in Aislados del Rio Lugan, Argentina (Anselmo *et al.* 1999),100% from river of France (Lemarchand and Lebaron 2003), 100% from river of Italy (Bonadonna *et al.* 2006), 53% from rivers and ponds around Sapporo city Japan (Savichtcheva *et al.* 2007), 3.8% from rivers in Netherland (Schets *et al.* 2008), 10 % from rivers and lakes of New Zealand(Till *et al.* 2008) , 54% from watershed in USA (Patchanne *et al.* 2010), 96% in river Suwannee in U.S.A. (Rajabi *et al.* 2011), 8.5% in Oldman river Canada (Jokinen *et al.* 2011), 15.4% in Grand–Lahou lagoon Africa (Adingra *et al.* 2012) and

63.7% from Mezan river Africa (Awah *et al.* 2013). Arvanitidou *et al.* *(*2005) noticed 41.4% *Salmonella* in warmer and 5.4% *Salmonella* in colder months Axion river in Northern Greek.

Spital distribution of *Salmonella* in KShipra river

Total five species of Salmonella were isolated viz. *S.anatum*, *S.typhimurium*, *S.typhi*, *S.paratyphi A* and *S.paratyphi B.* Among total annual count of *Salmonella* strains and their occurrence in entire Kshipra river *S.anatum* was the highest (34.34%) which is the main cause for Salmonelosis and Gastroenteritis. Second highest was *S. typhimurium* (28.08%) followed by S.typhi (20.20%) which is responsible for causing typhoid fever. However, less count of *S. paratyphi* A (7.87%), and *S. paratyphi B* (9.48%) were observed (Fig.1). Higher counts of *S. anatum* are attributed to large amount of animal, human and faecal contamination which are the main cause of river pollution. *S.anatum* is the main cause of Salmonelosis and its values ranged from 28-193x10^3 CFU/100ml. The highest count of *S.antum* was reported at Ramghat and lowest at Kshipra village. Among total annual count of *Salmonella* strains and their occurrence in entire Kshipra river *S.anatum* was the highest (35.483%) which is the main cause for Salmonelosis and Gastroenteritis. Second highest was *S. typhimurium* (26.392%) followed by *S. typhi* (19.354%) which is responsible for causing typhoid fever. However, less count of *S. paratyphi A (7.87%),* and *S. paratyphi B (9.48%)* were observed. Higher counts of *S. anatum* are attributed to large amount of animal, human and faecal contamination which are the main cause of river pollution. Abass (2008) reported 22.7% *S. anatum* as most frequently found serotype from Euphrates river Iraq. Patchanee *et al.* (2010) isolated 18.3% *S. anatum* from rivers of USA. *Salmonella typhimurium* is a non-typhoidal bacteria present in Kshipra river as second dominant species which is contributed by 28.08% of the total Salmonella count (Fig.1). It was found between range of 16 - 154 x 10^3CFU/100 ml. Saxena *et al.* (2013) reported *S.typhimurium* to be most common serovars from Ganga river. Kalaiyarasu (2013) isolated *S.typhimurium* from Ganga river India. Simental and Martinez-Urtaza (2008) isolated 39% S.typhimurium from rivers of Mexico. Jimenez *et al.* (1989) detected *S.typhimurium* from Mameyes river Purto Rico.

Salmonella typhi the main causative agent of typhoid fever is a member of *Salmonella* whose *enterica* subspecies is *enterica* and subtype is *typhi*. The main source of contamination of *S.typhi* is via food and water. The present study reports S.typhi within a range 2-73x 10^3 CFU/100ml. Abass (2008) observed 3.6% *S.typhi* from Euphrates river water Iraq and Sears *et al.* (1984) reported 11% of *S. typhi* from irrigation polluted water of Santiago Chile.

Comparatively a higher count of *S. typhi* about 19.35% is observed which correlates with higher pollution status of river Kshipra. *Salmonella* typhi were observe to increase in monsoon (Authur *et al.* 2015), however in present study higher count of *S.typhi* is registered in Summer. Tambekar *et al.*(2014) reported *S.typhi* from Wardha, Wainganga and Penganga river, India. Divivedi *et al.* (2014) recorded presence of *S.typhi* in river Khan which is a tributary of river Kshipra. Rani *et al.* (2014) recorded S.typhi from Ganga river, India which ranged from 185-39, 655 GE/100ml.

Other important *Salmonella* species includes *Salmonella paratyphi A* and *Salmonella paratyphi B*. Both of them are pathogenic and their route of contamination is via use of contaminated food and water or by inhalation of bacteria. 7.87% of *S. paratyphi A* and *9.48%* of *S. paratyphi B* were reported out of which *S. paratyphi A* causes paratyphoid fever and *S. paratyphi B* causes enteric fever. Occurrence of *Salmonella paratyphi A* at various sites of river kshipra out of total Salmonella count ranged from 3 to 67 CFU/100 ml, whereas *S. paratyphi* B varied between the range of 6 to 85 CFU/100 ml. Ahiwale *et al.* (2013) reported *S. paratyphi* B from surface water of Pavana river India. *S.paratyphi B* has been detected in surface water in France (Baudrat *et al.* 2000) and Italy (Bonadonna *et al.* 2006). Abass (2008) observed *S. paratyphi* A (4.6%) and *S. paratyphi* B (5.5 %) in Euphrates river Iraq. Onde *et al*. (2013) reported *S. paratyphi* A 96.9% from water bodies of Tanzania.

Temporal variation in *Salmonella* count

In Kshipra river the overall count of Salmonella varied throughout the year. Higher count of *Salmonella* were reported at Ramghat (24-91x10^3 CFU/100ml, Fig2C.), Mangalnath (9-58x10^3CFU/100ml Fig 2D) and Triveni (9-61x10^3 CFU/100ml Fig2B) whereas lower count is reported at Mahidpur (1-13x10^3CFU/100ml Fig 2 E) and Kshipra village (1-18x10^3CFU/100ml Fig 2A). Higher count at all sites was reported in the month of june and lower counts were reported in the months of November and December. The simple reason for higher number of strains in summer may be due to reduced water level in summer which leads to an increased nutrients concentration, pollution load and reduction of water flow. Awah *et al.*(2013) recorded maximum *Salmonella* count during May in Mezan river in Africa. It is possible that water velocity reduces in dry season, faecal bacteria accumulate and settle as a result of greater contact between water and sediments which enables significant sediments-water exchange (Mitsch and Gosselink 2000). Climate is one of the factors that might explain differences in abundance and diversity of *salmonella* species isolates between several locations (Rolland and Block, 1980). Polo *et al.* (*1999) and* Adingra *et al.* (2012) pointed out that the presence of *Salmonella* is known to increase with high level of rainfall that is, in rainy season. Tracogna and Losch (2013) observed that *Salmonella* species does not depend on environmental parameters like temperature because only small variations in temperature occurred through out the year in Argentina. Since, India is a tropical country where large variation in environmental factors like temperature and humidity can be seen which are responsible for variation in *Salmonella* count. *Salmonella* has been detected in different percentages by several authors in surface water ranging from 26.66% Salmonella in river water and 45% in pond water in Trivandrum district of Kerala India (Aruni and Prabakaran 2014), 62.9% in Aislados del Rio Lugan, Argentina (Anselmo *et al.* 1999),100% from river of France (Lemarchand and Lebaron 2003), 100% from river of Italy (Bonadonna *et al.* 2006), 53% from rivers and ponds around Sapporo city Japan (Savichtcheva *et al.* 2007), 3.8% from rivers in Netherland (Schets *et al.* 2008), 10 % from rivers and lakes of New Zealand(Till et al. 2008) , 54% from watershed in USA (Patchanne et al. 2010), 96% in river Suwannee in U.S.A. (Rajabi *et al.* 2011), 8.5% in Oldman river Canada (Jokinen *et al.* 2011), 15.4% in Grand–Lahou lagoon Africa (Adingra *et al.* 2012) and 63.7% from Mezan river Africa (Awah *et al.* 2013). Arvanitidou *et al.*(2005) noticed 41.4% Salmonella in warmer and 5.4% Salmonella in colder months Axion river in Northern Greek.

Occurrence of Salmonella with relation to water quality

In the present study seasonal variation of atmospheric temperature ranged between 15.8^0C-38.2^0C, water temperature between 15.3^0C-30.8^0C, pH within 7.9 -8.7 and dissolved oxygen was found between a range of 4.1-7.8 mg/litre. Biological oxygen demand was found within a range 8-37.6 mg/litre, Chemical oxygen demand ranged between 25.6-153.9 mg/litre. Lower values of dissolved oxygen, higher values of biological oxygen demand and chemical oxygen demand were observed at Ramghat and Mangalnath study sites (Table 1). This finding is well supported by a high microbial count at these sites, which indicates pollution load in the water body. However, high dissolved oxygen, lower biological oxygen demand and chemical oxygen demand was found at Kshipra village indicating comparatively less polluted with respect to other sites. As far as seasonal trends are concerned low dissolved oxygen were observed in summer because of increased temperature which decreases gas solubility of water (Bhattaraj, 2008). High biological oxygen demand and chemical oxygen demand values were observed in summer which is due to low water level, enrichment of nutrients and organic matters which supports microbial growth. During summer season, more mass baths and worship rituals are performed in the river due to which an increased organic load and microbial count were observed. The occurrence of *Salmonella* strains in river Kshipra is positively correlated with temperature, pH, BOD, COD and turbidity and negative correlation with dissolved oxygen (Table-2), water quality index (WQI) and transparency is observed . WQI ranged from 18-35 where as lowest WQI was reported at Ramghat in summer and highest at Kshipra village during winter, lower WQI indicates higher pollution load in the river (Table-2). Sharma *et al.* (2014) recorded WQI values 32-42 in Hindon river U.P. and categorized all locations of Hindon river to have bad water quality (Oram, 2007). In the present study values of Shannon-Weivner Index ranged from 0-1.382 at Kshipra village, 1.011-1.504 at Triveni, 0.844-1.538 at Ramghat, 0.943-1.502 at Mangalnath and 0.636-1.501 at Mahidpur. Eveness ranged between 0-1.00 at Kshipra village, 0.888-0.994 at Triveni, 0.727-0.980 at Ramghat, 0.858-0.991 at Mangalnath and 0.86-1.00 at Mahidpur. Maximum values of diversity indices were reported in summer and minimum in winter (Table-2). Alam (2013) observed higher values of Shannon-Weaner Index and Eveness for microbial diversity which were high during summer and low during winter. Hughes (1978) concluded that this index was useful for community structure but could not stand alone for assessing water quality. However on the contrary Balloch *et al.* (1976) pointed diversity index to be a suitable indicator for water quality. Margalef (1964) noticed diversity to be within 1-2.5 in eutrophic lakes and up to 4.5 in oligotrophic lakes. Similarly in the present study values of diversity indices and water quality index indicate eutrophic status of the river Kshipra.

Impact of anthropogenic activities on *Salmonella*

Environmental status of Kshipra river is influenced by various factors like urbanisation, industrialisation, accumulation of effluents, intense agricultural operations and faecal contamination. The count of *salmonella* is known to increase with these activities. So, a higher count of *Salmonella* is reported at different studied sites of Kshipra river. Lack of proper sanitation facilities in urban cities has been citied as the main cause of high bacterial pathogens in rivers transversing major cities in the world. Million litters of untreated sewage are discharged in the river Kshipra which carries high bacterial load. The occurrence of *Salmonella* is correlated with proximity of water contamination by sewage discharge and anthropogenic activities. About 12-15 lakh population of Dewas and Ujjain district depend on water of river Kshipra for irrigation, domestic and drinking purpose. Crops irrigated by this water are consumed by inhabitants of these and neighbouring cities which gives rise to outbreak of water born diseases. High values of *Salmonella* are obtained from Ramghat, followed by Mangalnath and Triveni. These increased values are evident because of high anthropogenic activities and human interventions viewed at these sites (Table1). Ramghat is the main bathing centre of Ujjain city where many festive mass baths, accompanied by various worship rituals like flower dumping, ashes dumping etc. are performed. Triveni also witnesses mass baths on different occasions which are participated by pilgrims across the world. The site is demarked by presence of a Shani temple and local crimnetorium. At this site oil leakage is observed as a result of which oil directly enters into the river increasing pollution load of the river. This study site is also the meeting point of river Khan which receives about 1500 m^3 of textile effluents having all poisonous textile dyes with oil and grease resulting in higher BOD and COD. At Sawer about 4000 m^3 sludge is added into Khan river. Water from here is drawn for irrigation of about 600 acres for growing vegetables (Rao *et al.*1992). Similarly at Mangalnath also different worship rituals are observed which increase nutrient concentration, organic pollution and microbial load of the river. Presence of brick making activity is observed about 100 brick kilns have damaged the flood plains of the river. These pollutants enter the river and contribute to the increased pollution at Ramghat and Mangalnath sites. Kshipra village is near to the origin point of Kshipra river because of which a lower count of *Salmonella* is observed over here. However, this site is marked by comparatively less anthropogenic activities. Similarly, lower counts of *Salmonella* are observed at downstream of Mahidpur which are attributed to self-purification capacity of the river and also because of the distance of 150 km from the origin point which reduces the number and concentration of bacteria.

Salmonella prevalence with relation to health status

Typhoid and Enteric fevers are systemic diseases caused by human host adapted *S.typhi*. Both epidemic and endemic incidences of typhoid is a major health issue resulting in high economic burden, mortality especially in a developing country like India. In the present study 23-25% cases of typhoid and 15-18% cases of enteric fever were registered throughout study period. About 25-28% of cases of salmonellosis were reported and high incidence of gastrointestinal disorders were also found. Higher cases were reported during summer season due to increased count of *S.typhi*. Similarly, an epidemiological survey conducted during mass bath in Ganga river reported total 5368 cases of water borne infections due to deteriorated microbiological quality of Ganga water (Tyagi *et al.* 2013). During Summer 2002 within a seven week period 5963 cases of Typhoid fever were reported in Bharatpur Nepal (Lewis *et al*. 2005). The outbreak was found to be associated with high *S.typhi* counts in municipal water. In Africa high count of *S.typhi* in drinking water was found to be associated with high cases of typhoid fever more than 100 cases per 10,000 individuals were registered (Crump *et al.*2004). According to CDC data in USA from 1971-2000 an increase of 6% in typhoid cases were observed which was less than that in developing countries (Craun *et al.*2004). Cut in England *Salmonella* was never associated to water borne outbreak in England and Wales from 1992 to 2003 (Smith *et al.* 2006) indicating that *Salmonella* count and infection are greater in developing countries than developed countries.

In developing countries, the main source of river pollution is mainly via faecal contamination, discharge of untreated waste and sewage in the water body, lack of proper sanitation facilities and agricultural run off. However, in such countries lack of water supply, self- sustaining decentralised approaches including point of chemical and solar disinfection, safe water storage and behaviour changes are indicated as reliable options to directly target most affected population and reduce water-born disease burden through improved drinking water quality (Mintz *et al.*2001). In developed countries, industrial effluents, agricultural runoff and mixing of pesticides and fertilizes with the river or tap water contributes as a major source of water contamination. In such industrialised countries, the success of applied control strategies is confirmed by small number of water- born outbreak caused by various water born microbes Nevertheless, outbreaks caused by microbial contamination of drinking water still result in substantial human and economic cost in these countries (Berg 2008, Risebro *et al*. 2007). In a resource constrained country like India, surface water is used for drinking, bathing, recreational and holy activities. However, factors like sewage and waste discharge, industrial effluents, agricultural runoff contribute to increase the level of pollution in Indian river, but another factor which is a very important reason for pollution of Indian river system is the occurrence of religious festivals conducted on the banks of major Indian holy rivers like Ganga, Yamuna, Godavari, Kshipra etc. The river water gets flooded with many worship rituals and this water if used without proper treatment can lead to various health hazards. River Kshipra hosts the Mahakumbh mela which is a religious festival organized in every twelve years attracting millions of tourists and devotees from all around the world to take bath in this sacred river, this gives rise to massive mass baths further depleting water quality. River Khipra is known to originate from lap of God Brahma and so enjoys status of Goddess in Hindu mythology so dumping of body ashes and statues of different God and Goddesses is an evident act observed at the banks of this river. These activities certify that in holy rivers of India mode and nature of pollution is different from water bodies across the world.

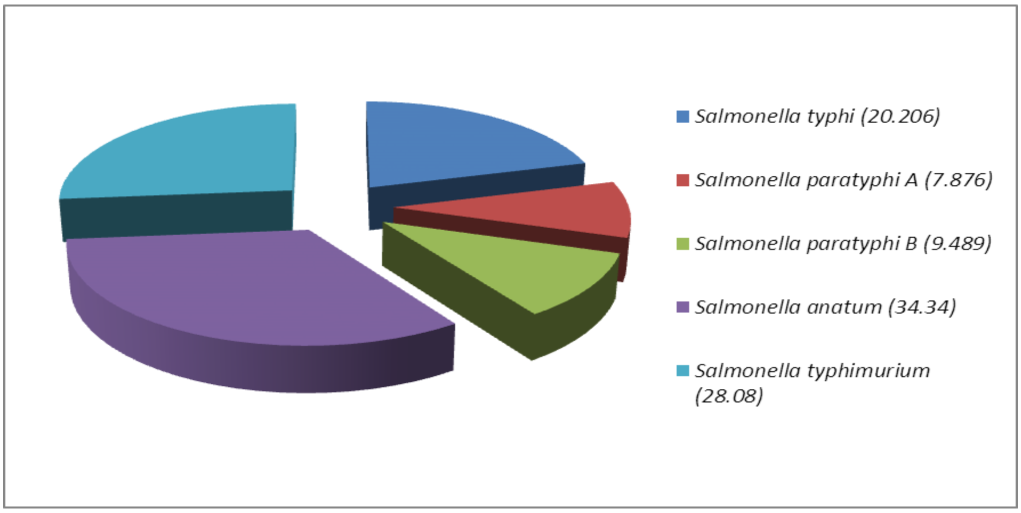

Fig 1.Percentage composition of *Salmonella* species in Kshipra river.

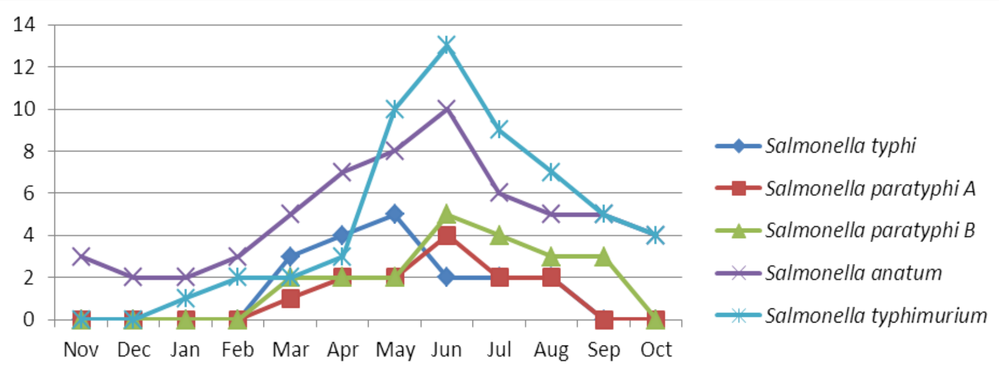

Fig. 2A - Monthly variations in *Salmonella* count X (10^3 CFU/100 ml) at Kshipra village study site)

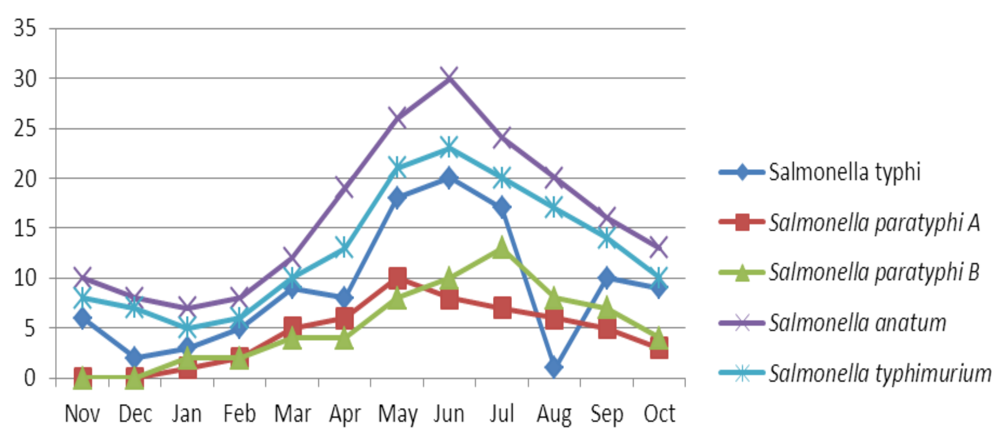

Fig. 2B - Monthly variations in *Salmonella* count X (10^3 CFU/100 ml) at Triveni study site

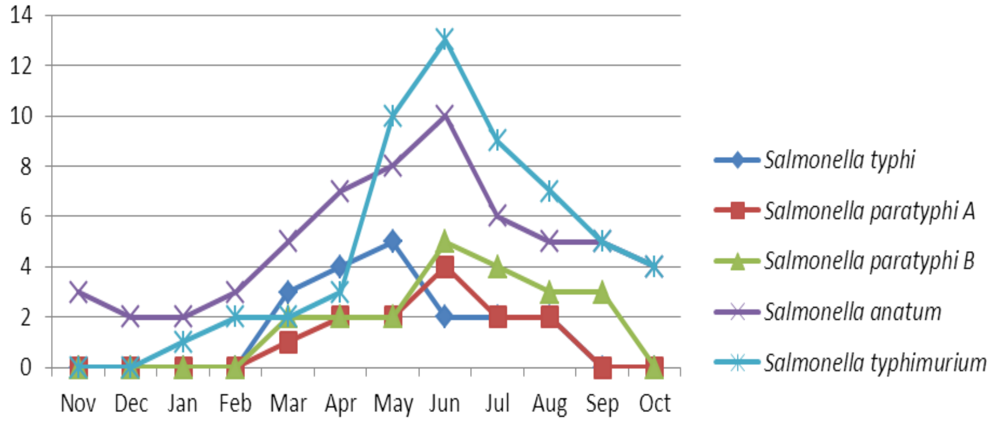

Fig. 2C - Monthly variations in *Salmonella* count X (10^3 CFU/100 ml) at Ramghat study site

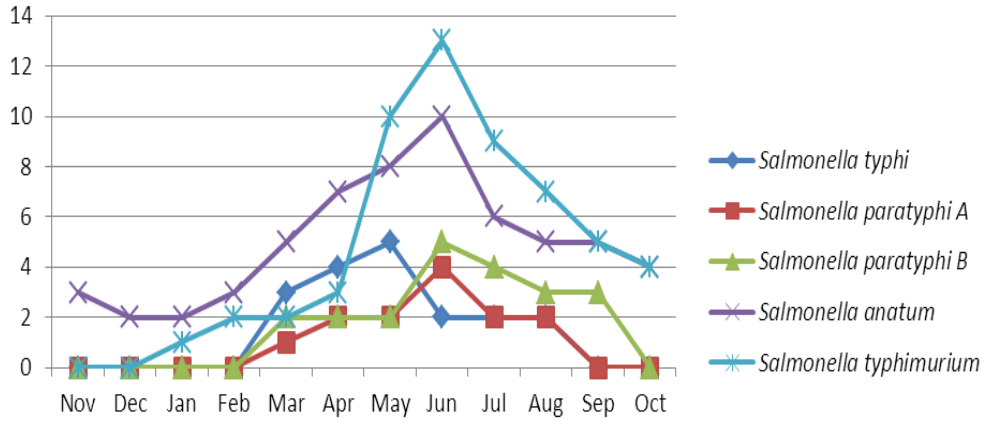

Fig. 2D - Monthly variations in *Salmonella* count X (10^3 CFU/100 ml) at Mangalnath study site

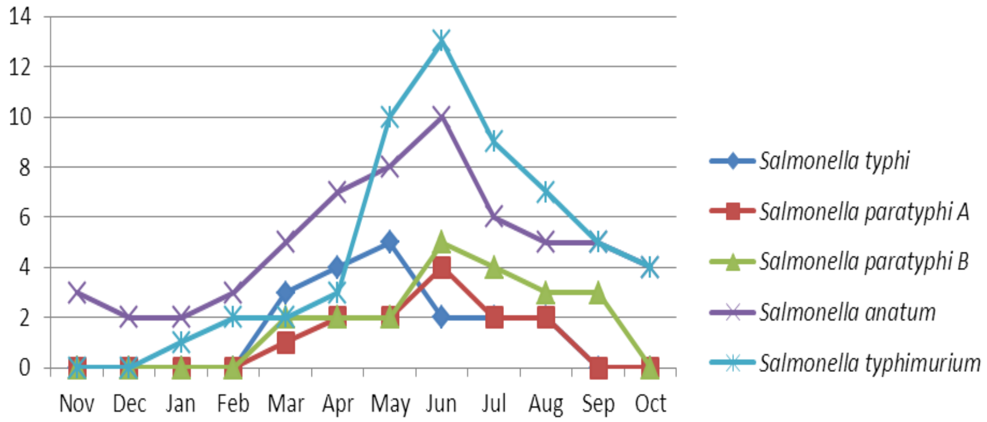

Fig. 2E - Monthly variations in *Salmonella* count X (10^3 CFU/100 ml) at Mahidpur study site

Table 1: Impact of water quality and anthropogenic activities on *Salmonella* count

S.No.	Parameters	Kshipra village			Triveni			Ramghat			Mangalnath			Mahidpur		
1.	Physico chemical Parameters	S.	M.	W.	S.	M.	W.	S.	M.	W.	S.	M.	W.	S.	M.	W.
a.	Air Temperature ° C	39	30.7	19.2	41.5	28.5	19.1	35.8	26.6	12.2	31.9	22.8	10.9	37.5	28.0	21.0
b.	Water Temperature ° C	30.25	28.17	18.50	32.4	23.7	17.6	27.2	22.2	14.6	27.8	20.5	10.9	27.8	17.9	27.6
c.	Dissolved Oxygen (mg/lit)	7.0	7.2	7.8	4.8	6.0	6.4	4.0	5.6	6.0	4.2	5.4	6.0	5.8	6.2	7.2
d.	Biological oxygen demand (mg/lit)	19.6	15.8	13.6	39.6	34.2	22.8	43.8	38.4	24.4	41.4	30.4	24.6	28.4	17.2	14.4
e.	Chemical oxygen demand (mg/lit)	28.3	27.9	25.6	130.8	80.6	64.2	166.4	110.4	88.2	138.2	82.6	72.8	88.6	74.6	45.8
f.	pH	8.5	8.3	8.0	8.6	8.2	7.9	8.8	8.5	8.0	8.8	8.2	7.8	8.7	8.4	8.0
g.	Turbidity (NTU)	25.0	25.7	14.0	35.0	26.0	18.0	40.0	31.0	19.0	38.0	37.0	20.0	36.0	24.0	14.0
h.	Total coliform (x 10^3 CFU/100ml.)	196	180	138	600	344	309	768	512	402	678	446	358	212	194	168
i.	Faecal coliform (x 10^3 CFU/100ml.)	106	97	74	280	172	152	296	238	202	298	203	182	112	102	89
j.	Transparency (cm)	47	40	86	41.5	36.8	82.2	35.1	37.5	68.2	38.2	34.1	68.2	48.0	39.0	71.0
2.	Water Quality Index	28	29	35	20	23	24	18	20	26	18	22	27	20	24	29
3.	Total *Salmonella* count (x 10^3 CFU/100ml.)	18	2.0	0	61	36	6	91	52	17	73	14	9	37	14	06
4.	Shannon Weiner Index (H')	1.37	1.098	0	1.504	1.43	1.093	1.593	1.171	0.844	1.501	1.271	0.943	1.501	1.073	0.636

5.	Evenness (H)	1.00	0.854	0	0.972	0.888	0.852	0.956	0.949	0.911	0.933	0.727	0.768	0.933	0.902	0.858
6.	Anthropogenic activities	+			+			+			+			+		
a.	Mass bathing	-			+			+			-			-		
b.	Flower dumping	-			+			+			+			-		
c.	Coconut dumping	-			+			+			+			-		
d.	Other rituals	+			+			+			+			-		
e.	Oil leakage	-			+			-			-			-		
f.	Ashes of dead bodies	-			-			+			-			-		
g.	Presence of crimnetorium	+			+			-			-			-		
h.	Domestic waste water disposal	-			+			+			-			-		
22.	Tributary with industrial and domestic waste (Khan river)	-			+			-			-			-		
23.	Agricultural runoff	-			+			+			-			-		
24	Boating	-			-			+			-			-		

Table-2: Correlation between physiochemical parameters and *Salmonella* species of Kshipra river

S.No	Parameters	*S.typhi*	*S.paratyphi A*	*S.paratyphi B*	*S.anatum*	*S.typhimurium*	Total *Salmonella*
1.	Atmospheric temperature	0.906	0.836	0.933	0.859	0.915	0.867
2.	Water temperature	0.956	0.904	0.970	0.922	0.962	0.942
3.	Transparency	-0.663	-0.549	-0.712	-0.585	-0.678	-0.630
4.	Turbidity	0.559	0.435	0.614	0.474	0.576	0.523
5.	Ph	0.877	0.799	0.907	0.824	0.886	0.855
6.	Dissolved oxygen	-0.952	-0.898	-0.970	-0.916	-0.958	-0.937
7.	Biological oxygen demand	0.885	0.810	0.915	0.835	0.895	0.864
8.	Chemical oxygen demand	0.841	0.754	0.875	0.782	0.851	0.816
9.	*S.typhi*	1	0.989	0.997	0.994	0.999	0.999
10.	*S.paratyphi A*		1	0.977	0.999	0.986	0.994
11.	*S.paratyphi B*			1	0.985	0.998	0.993
12.	*S.anatum*				1	0.992	0.998
13.	*S.typhimurium*					1	0.997
14.	Total *Salmonella* count						1

+ present -absent

(Correlation is significant at the level of 0.01 and 0.05).

CONCLUSION

The quality of water of river Kshipra was assessed with respect to the occurrence of *Salmonella* species and its relation to water quality. This was to ascertain that whether it meets local and international standards for safe human consumption. Standard bacteriological techniques were used to describe various *Salmonella* species in the water samples. It is also evident that water quality of Kshipra river in terms of *Salmonella* species is highly contaminated and is much above C.P.C.B. standard guidelines for drinking water and agricultural use. *S.anatum* was found to be the highest among total count of Salmonella strains. It is the main causative agent of *Salmonellosis*. High amount of *S.typhimurium* and *S. typhi* were also found. These cause Gasteroenteritis, enteric fever and Typhoid respectively. Higher Salmonella counts, accompanied by high BOD, COD, lower DO and water quality index certify increased pollution load in the river, Thus making river water unfit for consumption without proper treatment process. This in turn can pose many problems for people residing in close vicinity and can cause many water born diseases. Regular water monitoring, and public awareness is required to improve the present sanario. Disposal of coconut, flowers, industrial and city sewage should be totally prohibited in this holy river. This reaffirms the need for regular monitoring of microbial parameters of the water body, in order to minimize the risk of infection to exposed person. A proper action like Ganga Action Plan needs to be initiated by State and Central government for cleaning and conservation of this sacred river.

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