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Impacts of a Flash Flood on Drinking Water Quality: Sanitary Analysis of Drinking Water of Kuttanad Area Affected with Flood

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Abstract:- Kuttanad is an area of water logging and lies below the sea level. The level of water in this region is usually above the paddy fields that cover most of the region. Most people here are unaware of the health hazardous likely to occur during or after flood. In this study, we are trying to find out the impact of flood on sanitary quality of drinking water of Kuttanad area due to the heavy rainfall during 2018, the worst floods to hit in the last two decades that have shattered the Kuttanad region. The floodwater has resulted in the submergence of the entire region forcing displacement of people. Safe drinking water and proper sanitation are the two inevitable necessities for human health and natives usually depend on ground water for drinking purpose. But during the flood, ground watert able maybe mixed with flood water and become contaminated. Poor sanitation system has increased the contamination level and the contaminated water sources could spread out a number of water borne diseases. Considering the prevalent situation, this study was taken to evaluate water for parameters, namely total coliform groups, faecal coliforms, *Vibrio* and *Salmonella* species by conventional microbiological techniques. From the study we could deduce that the water resources were completely polluted or contaminated. 76.67 % of the analysed sample was found to be unsatisfactory for usage. Moreover, 30% of the analysed samples were found to have contaminated with *E.coli.* Around 83.34% of samples analysed were detected with the presence of *Vibrio* species. Among the samples of positive results, 56.67% of samples were detected with *Vibrio cholerae* and 23.34% of the positive samples were detected with the species of *Vibrio parahaemolyticus*. Of the samples that showed the presence of *Vibrio*, 23.34% showed the presence of both *V.cholerae* and *V.parahaemolyticus*. 26.67% of the samples were found to have shown positive results for *Salmonella* Species. Taking to account, the location and sanitation conditions, water sources may be contaminated by flood water. During flood many waterborne diseases spread out like Cholera, Dysentery, Diarrhoea, Typhoid etc.

Keywords:- *Kuttanad, Drinking Water, Flood, Waterborne Diseases.*

I. INTRODUCTION

Water is a critical factor upon which life sustains. Earth is a water planet but still only 2% is available for drinking purpose. Unclean water ranks at top of the world population problem (Goel and Grad, 2008). As per the World Health Organization (WHO), 2.6 billion people have no provision to clean water and moreover 3.4 million deaths are reported due to water borne diseases,mostly in children every year. Human health can be affected by ingestion of contaminated water either directly or indirectly and also by the usage of contaminated water for the purpose of personnel hygiene and recreation. The major drawback of these developing regions is the lack of provision for safe drinking water and almost 800 billion individuals are suffering from water borne diseases due to the consumption of unsafe drinking water (Ehsan Humayun, April 2015). The occurrence of pathogenic microbes in water is unhealthy and threatening. For example, bacteria present in the intestinal tracts warm blooded animals including humans, such as *Escherichia coli*, *Salmonella*, *Shigella*, and *Vibrio*, can contaminate the water source with sewage debris. The microbiological quality of surface waters are measured by the presence of indicator organism; among which faecal coliforms (FC) are the most commonly used as the bacterial indicator of faecal pollution. Faecal contamination in the water resources of coastal areas are gaining much importance (Byamukama et al., 2005).Worldwide coliform bacteria are used as indicators of faecal contamination (Naggar et al., 2003; El-veShenawy and Farag,2005) and hence, the possible presence of disease causing organisms (Tyagi et al., 2006; Sabae, 2006; Rosenfeld et al., 2006). Bacteria is said to be one of the major contaminants of water(Suthar et al., 2009). The faecal coliform group constitutes organisms, such as *Klebsiella* spp, *Enterobacter* spp and *Citrobacter* spp, which are not exclusively of faecal origin (Standard Methods, 1995). Faecal coliform bacteria are therefore considered to be the most important indicator of the presence of faeces (Maier et al., 2000). *E.coli* is considered as a good indicator of faecal contamination.*E.coli* is identified as the only species in coliform group found exclusively in intestinal tract of human and other warm blooded animals and excreted in high number approximately 10^9 per gram of sample (Geldreich, 1983). The pathogenic microbes, their toxic exudates, and other contaminants together, cause serious conditions such as

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cholera, diarrhoea, typhoid, amoebiasis, hepatitis, gastroenteritis, giardiasis, campylobacteriosis, scabies, and worm infections etc. Many infectious diseases are associated with faecal contamination of water and are a critical reason of morbidity and mortality worldwide (Leclerc et al., 2002; Theron and Cloete, 2002).

The method of analysing water to estimate the numbers of bacteria present in it and, if needed, to find out what sort of bacteria they are is called Bacteriological analysis of water. It indicates the biological quality of water. It is a microbiological analytical procedure which make use ofwater samplesto determine the most probable number of microoragnisms in it and draws inference from the results regarding the potability of the water. The procedure is routinely used to confirm the safety of water for human use.

Kuttanad being below the sea level receive the flood waters of the river systems like Periyar, Muvattupuzha, Meenachil, Pampa and Achenkovil, all originating from Western Ghats mountain ranges which receives south west and north east monsoonal rains. These rivers along with their tributaries traverses Kuttanad wetlands and Vembanad Lake before ending in the Arabian Sea. The organic matter transported and deposited here contributes to the uniqueness of the Kuttanadan ecosystem in addition to its location near equator, equitable temperature regime, high rainfall and high solar radiation throughout the year. Most of the Kuttanad area remain waterlogged almost throughout the year and are subjected to flood during the rainy season.

The present study is about to find the water quality of Kuttanad area after the flood that affected Kerala in 2018. Mostly the parts of lower Kuttanad was severely affected by the flood. The contamination of the drinking water source increase which are mainly well water in those areas. Microbiological analysis was conducted for the identification and enumeration of coliform bacteria. Tests were also conducted for the detection and isolation of *Vibrio* and *Salmonella* species.

II. METHODOLOGY

Sampling area: Kuttanad is a highly complex, dynamic and unique rice growing agro-climatic tract of Kerala lying 0.5 to 2.5 m below Mean Sea Level (MSL). It extends between North latitudes 9 0 8‟ and 9 0 52‟ and East longitudes 760 19‟ and 760 44‟, comprises the area of 54 revenue villages spread over Alappuzha, Kottayam and Pathanamthitta districts. The total geographic area of the region is 1100km. Kuttanad is bordered by Kaduthuruthy- Vaikom road in the north, Kaduthuruthy - Kottayam -Mavelikkara railway line in the east, Mavelikkara - Haripad - Thottapally road in the south and Thottapally -Alappuzha - Thaneermukkom road in the west. Thirty samples from different Taluks of Kuttanad were selected for this study.

Media used: MacConkey broth, Eosine Methylene Blue agar, Alkaline Peptone Water, Buffered Peptone Water, Thiosulfate Citrate Bile Agar (TCBS agar), Rappaport-Vassiliadis Broth (RV broth), Xylose Lysine Deoxycholate Agar (XLD agar).

Analytical methods:

Sanitary analysis of drinking water: This was done by multiple tube fermentation method or multiple tube method (MPN).It the most commonly used test for the analysis of microbiological quality of water samples. The test is primarily used to detect coliforms, which are indicator organisms for faecal contamination. They make up 10% of intestinal microflora of most animals. The test has three stages namely presumptive, confirmed, and complete test. MacConkey broth (which is the media used) tubes are incubated with water samples and the MPN index of the sample is calculated. The complete test follows by inoculation of EMB agar plate, Nutrient agar plate and MacConkey broth and preparation of a gram stain slide from nutrient agar (NA) slant, is used to establish that Coliform bacteria are present in the sample. The complete process including the confirmed and complete test requires at least 3 days for incubation.

Isolation of *Vibrio* from samples of drinking water: For Vibrio species isolation, 250mL of water sample were filtered through 0.22 µm membranes. Membranes were aseptically transferred in 225 mL of alkaline peptone water (APW). Incubate the sample mixture at 35°C. After 6-8 hour incubation, transfer a loopful from the surface pellicle of APW culture to the surface of a dried TCBS (Thiosulfate Citrate Bile Salts Sucrose agar) plate and streak in a manner that will yield isolated colonies. Incubate TCBS plates at 35°C for18-24 hours. Examine the TCBS plates for Vibrio colonies. Vibrio cholerae colonies appear large, smooth, yellow and slightly flattened with opaque centres and translucent periphery and Vibrio parahaemolyticus appears as round, opaque, green or bluish colonies 2-3mm in diameter.

Isolation of *Salmonella* from drinking water: For Salmonella spp. isolation, 250mL water was filtered through the 0.22 µm pore-sized membrane until it became occluded. Membranes were aseptically transferred to homogenized mixture of 225mL buffered peptone water (BPW). Incubate the sample mixture at 35°C for 24 hours. Transfer 0.1ml to 10ml of Rappaport-Vassiliadis (RV) medium. Mix well. Incubate RV medium at 42°C for 24 hours in a water bath. Mix and streak a loopful of growth from RV medium on Xylose Lysine Deoxycholate (XLD) agar. Incubate plates at 35°C for 24 hours. Examine all the plates for presence of Salmonella colonies - Pink colonies with or without black centres.

Biochemical tests:The following tests were done for the partial characterization of *E.coli*, *Salmonella* and*Vibrio* species isolated from the water samples: Carbohydrate fermentation tests,Indole test,Methyl Red (MR)-Voges

Proskauer (VP) test, Citrate test, Catalase test and Oxidase test etc.

III. RESULTS AND DISCUSSION

Table no:1 Summary of analysis of different samples of Kuttanad area

Sl No.	Place	*E.coli*	*Vibrio species*	*Salmonella*
1	Champakulam	Present	*V. Cholerae*	Present
2	Chenamkary	Absent	*V. Cholerae& V. Parahaemolyticus*	Absent
3	Edathua	Present	*V. Cholerae& V. Parahaemolyticus*	Present
4	Kainady	Absent	Absent	Absent
5	Kannady	Present	*V. Cholerae*	Present
6	Kavalam	Present	*V. Cholerae*	Present
7	Kidangara	Absent	*V. Parahaemolyticus*	Absent
8	Kodupuna	Absent	*V. Cholerae& V. Parahaemolyticus*	Absent
9	Koolipara	Present	*V. Cholerae*	Present
10	Krishnapuram	Absent	*V. Cholerae& V. Parahaemolyticus*	Absent
11	Kumaramkary	Present	*V. Cholerae*	Present
12	Kunnamkary	Absent	*V. Cholerae*	Present
13	Kurishumoodu	Absent	*V. Cholerae*	Absent
14	Mampuzhakary	Absent	*V. Cholerae*	Absent
15	Manalady	Absent	Absent	Absent
16	Mancompu	Absent	Absent	Absent
17	Mithrakary	Absent	*V. Cholerae& V. Parahaemolyticus*	Absent
18	Muttar	Absent	*V. Cholerae*	Absent
19	Narakathara	Absent	*V. Cholerae*	Absent
20	Nedumudi	Absent	*V. Cholerae*	Absent
21	Neelamperoor	Absent	*V. Cholerae*	Absent
22	Pallikuttuma	Present	*V. Cholerae*	Present
23	Pallathuruthy	Absent	*V. Cholerae& V. Parahaemolyticus*	Absent
24	Paral	Absent	*V. Cholerae& V. Parahaemolyticus*	Absent
25	Pullangadi	Present	*V. Cholerae*	Present
26	Ramankary	Absent	*V. Cholerae*	Absent
27	Thakazhy	Absent	Absent	Absent
28	Valady	Present	*V. Cholerae*	Absent
29	Veliyanadu	Absent	Absent	Absent
30	Vezhapara	Absent	*V. Cholerae*	Absent

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Table no 2: Biochemichal characteristics of Isolates

Sl No.	Test	*E.coli*	*V. cholerae*	*V. Parahaemolyticus*	*Salmonella*
1	Catalase	+	+	+	+
2	Oxidase	-ve	+	+	+
3	Motility	Motile	Motile	Motile	Motile
4	Indole	+	+	+	-ve
5	Methyl red	+	-ve	+	+
6	Voges- Proskauer	-ve	+	-ve	-ve
7	Citrate utilization	-ve	+	-ve	-ve
8	Urease	-ve	-ve	+	+
9	Hydrogen sulphide	-ve	-ve	-ve	-ve
10	Starch hydrolysis	-ve	+	+	-ve
11	Gelatin hydrolysis	-ve	+	+	-ve
12	Nitrate utilization	+	+	+	-ve
13	Coagulase	-ve	ND	ND	-ve
14	Glucose fermentation	A+G	+	+	A+G
15	Xylose fermentation	A+G	-ve	-ve	A+G
16	Lactose fermentation	A+G	-ve	-ve	A+G
17	Sucrose fermentation	A+G	+	-ve	A+G
18	Maltose fermentation	A+G	+	+	A+G
19	Mannitol fermentation	A+G	+	+	A+G
20	Galactose fermentation	A+G	+	+	A+G
21	Fructose fermentation	A+G	ND	ND	A+G
22	Sorbitol fermentation	A+G	-ve	-ve	A+G
23	Arabinose fermentation	A+G	-ve	-ve	A+G

Key

+ = Positive	-ve = Negative	A+G= acid and gas production	ND = Not determined

The 2018 Kerala flood was among the most severely affected floods of the state. Almost lasting for about two weeks, the flood affected the economic and ecological strata. Wide range of destruction was followed by the flood. The flood water contained organic and inorganic waste products in large quantities. The flood water all along with the waste was deposited in the low-lying areas of the state. Kuttanad around 4-10ft below sea level was among the major places that were affected. Being thickly populated and a major contributor to the state's food crop production Kuttanad faced immense stress all throughout. All the topographical factors contributed to the increase of contamination of water resources of the Kuttanad area.

Sanitary analysis of drinking water of different Taluks in the Kuttanad area where flood was severely affected was carried out by multiple tube fermentation method (MPN). 30 samples were collected from different Taluks of Kuttanad and was transported to the laboratory and processed within 24 hours of collection. Further samples were analysed for the detection and isolation of *Vibrio* and *Salmonella* species. Water borne diseases such as cholera, salmonellosis etc. were expected in post flood period.

Tubes were looked for acid and gas production. The number of tubes with acid and gas production for each volume of water added were noted and the most probable number of total coliforms were calculated according to the standardized probability table for all samples of water and the results obtained were compared to the interpretation table. Of the 30 water samples obtained from the different Taluks of Kuttanad; samples from five places had shown MPN index ≥1100 for total coliforms per 100mL which make up 16.67% of the total samples analysed. Among these five places, water from Champakulam had shown the highest MPN index ie., $1.1x10^5$ per 100 ml of sample. Followed by water samples from places such as Kannady, Kavalam, Pullangady, and Narakathara. All the above places except Narakathara showed the presence of *E.coli*. Among the samples analysed 30% of the samples showed MPN index from 460-150.

E.coli was detected in 9 samples viz.smaples from Champakulam, Kannady, Kavalam, Pullangady, Kulipura, Pallikuttumma, Edathua, Valady, and Kumaramkary, which constitute 30% of the whole samples. These samples on culturing on the differential media; EMB (Eosin Methylene Blue) agar showed colonies with green metallic sheen and other characters of *E.coli*. (fig 1)

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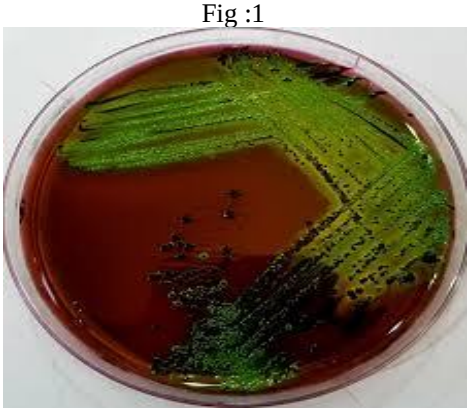
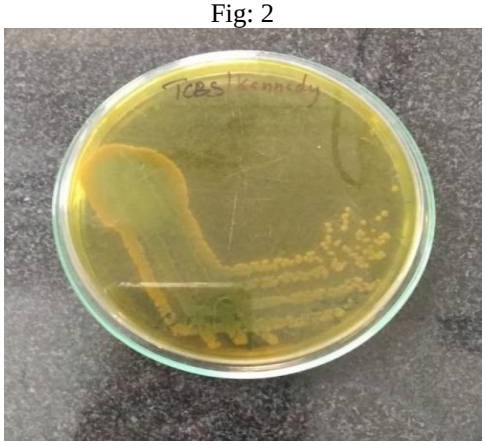
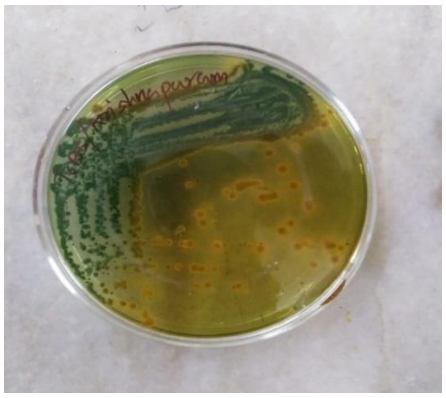
Fig :1



The 2011 WHO guidelines for drinking water give a tolerance range for *E.coli* in drinking water. Although it is preferable that drinking water contains no *E.coli*; samples containing less than 10 *E.coli* colonies per 100ml are considered of low risk. Chin Yik Lin (2010), conducted a bacteriological analysis and results showed that the quality of water was poor with faecal coliform count exceeding the WHO permissible limits for drinking water. Coliforms in water might be the indication of improper sanitation facilities located too close to the wells. The samples that are of high risk are hence deduced to have faecal contamination. Out of all the analysed samples, 23.34% of samples were interpreted as suspicious and 76.67% samples were unsatisfactory for use. This shows the vulnerable hygienic conditions of the areas under investigation. samples were subjected to tests for the detection and isolation of *Vibrio* and *Salmonella* spp and the results were noted. From the results we can conclude that around 83.34% of samples analysed were detected with the presence of *Vibrio* species. Among the samples of positive results, 56.67% of samples were detected with *Vibrio cholerae* species on the differential medium of TCBS agar and 23.34% of the positive samples were detected with the species of *Vibrio parahaemolyticus.*(fig 2). Of the samples that showed the presence of *Vibrio*, 23.34% showed the presence of both *Vibrio cholerae* and *Vibrio parahaemolyticus* on TCBS agar.

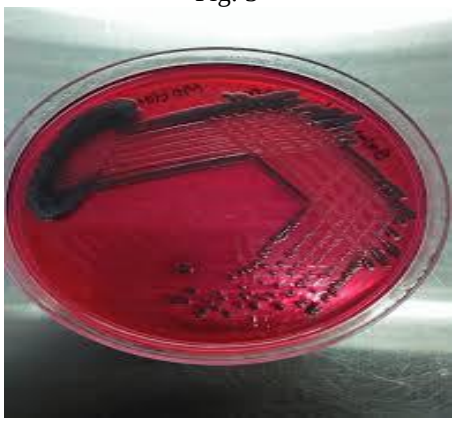
Fig: 2





Out of the 30 sample analysed for *Salmonella* species, 8 samples (26.67%) were found to have shown positive results (fig 3)

Fig: 3



Of the 30 samples analysed, 26.67% of samples showed the presence *E.coli,Salmonella and Vibrio sps.*. These places are Champakulam, Edathua, Kannady, Kavalam, Koolipara, Kumaramkary, Pallikuttumma and Pullangadi. The samples from Valady shows the presence of *E.coli* but showed negative results for *Salmonella* test. Partial characterization of isolates of *E.coli, V.cholerae, V.parahaemolyticus* and *Salmonella* were done with biochemical tests.

The reason behind the high amount of bacterial contamination might be the inadequate maintenance of water resources and the discharge of untreated sewage into riverine bodies. During the period of flood different water resources overflowed resulting in the mixing of water from different sources. Also added to this, Kuttanad being a low lying area act as basin were water from other places as well flow into it finally to drain into the Arabian Sea.

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IV. CONCLUSION

The present study indicates the polluted conditions of water resources of Kuttanad area which will have serious effects on the health conditions of the inhabitants. From the study we could deduce that the water resources were completely polluted or contaminated. 76.67 % of the analysed sample was found to be unsatisfactory for usage. By practicing proper waste disposal, creating storm water drains, controlling sewage spills and avoiding open defecation the contamination can be reduced to a large extend and thereby increase the well water quality. Ensure time to time monitoring of the microbiological quality of drinking water to prevent outbreak of enteric diseases.

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