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ALUM, AN INORGANIC POWERFUL COAGULANT TO DISINFECT PAMPA RIVER WATER SYSTEMS

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ABSTRACT: Pamba River is the third largest river in Kerala with a length of about 176 km and a catchment area of about 2,235 sq. km. It is one of the most polluted river system in Kerala. The present study is a pioneering effort to evaluate the feasibility of incorporating Alum coagulant as an effective interim treatment strategy for the removal of coliforms and thereby bringing the process of super chlorination down to low dose chlorination. Pamba river water with high amount of fecal coliform and suspended solids was subjected to chlorination dosage of 10 mg/l for 30 minutes contact time followed by dechlorination with sodium thiosuphate. Super chlorination resulted in the doubling of COD indicating the formation of more recalcitrant highly toxic chlorination derived by-products. The newly formed compounds were extracted and were subjected to structural analysis by FT/IR. The data obtained indicated the presence of Trihalomethane, Haloaceticacid as by-products. The Alum treatment proved that there is remarkable reduction in coliforms at 30 mg/l for 30 minutes contact time without affecting COD. Hence for Pamba River, an integrated alternative treatment strategy using Alum to bring down the toxicity level caused by super chlorination can be deployed.

Key words: *Alum, Super chlorination, Trihalomethane, Haloaceticacid FT/IR.*

1. INTRODUCTION

Water is one of the most important commodities which Man has exploited than any other resource for sustenance of his life. Most of our demand for water is fulfilled by rain water which gets deposited in surface and ground water resources. Pamba is one of the most important and vital riverine systems in southern Kerala. The famous shrine of Sabarimala is situated in the hills of Pamba plateau which is one of the most popular pilgrim centers in South India. Lack of facilities for sewage collection and treatment, at Sabarimala is the major cause for the pollution of Pamba River. The pollution is mainly due to human excreta and biodegradable waste like vegetable wastes, discarded clothes, food wastes etc. Indiscriminate disposal of used plastic bottles forms the major portion of the non-biodegradable waste. The gathering of very large crowds over a short period of time every year in an ecologically sensitive area has given rise to various environmental problems (Prasannakumar *et al* 2012)

Coagulation and flocculation play a dominant role in many water and wastewater treatment schemes, including those incorporating membrane treatments. Rapid development of industrialization and human activities has led to increase the discharge of waste and wastewater containing organic and inorganic pollutants. Waste water disinfection is generally considered an important stage of waste water treatment. Regular monitoring of water quality should be carried out to ensure the chlorine residual and Coliforms and maintain the recommendations by the agencies such as EPA (Farooq *et al*, 2008). The chlorine residual concentration must be 0.5 mg/l at the entrance into the distribution system and

0.25 mg/l at consumers. Chlorination could remove fecal coliforms very effectively but it has a disadvantage of generating toxic disinfection byproducts (Anju and Atul, 2007). More than one billion people do not have access to a safe water supply within 1 km of their homes, relying instead on unprotected lakes, streams or shallow wells to meet house hold needs.

2. MATERIALS AND METHODS

2.1. Chlorination

A typical chlorination experiment consisted of dosing different portion of the sample with varied chlorine amounts and mixing on a multi position magnetic stirrer for 30 min. A control sample to which no chlorine was added, was also processed similarly. At the end of contact time residual chlorine was measured and a calculated amount of 0.025 N sodium thiosulphate solution was added for complete dechlorination. Then a sampling programme was conducted to investigate the formation of disinfection byproducts (DBPs) and dissolved organic carbon. Changes in the concentration of dissolved organic carbon, the Trihalomethanes potential, and the halo acetic acid potential in the finished drinking water were evaluated.

2.2. Solvent extraction

Samples after chlorination was subjected to solvent extraction and the extracted samples were spectroscopically analyzed. The samples were collected in the sterilized cans of 2.5 litters. The different parameters BOD, COD, TOC etc. were analyzed according to the standard methods adopted by APHA and AWWA.

2.3. Alum Treatment

Alum is generally accepted as a coagulant and also slightly induces coliform sedimentation along with suspended solids. In the present attempt alum at different concentrations were tried and its effect on the COD and MPN of the water sample was quantified. Aluminium sulphate or Alum is used as a flocculent to remove unwanted colour and turbidity from water supplies. Alum treatment of the contaminated water sample was done according to APHA (1971). The 100 ml of the water sample was mixed slowly with the accurately weighed alum and was mixed for 30 minutes. It was kept for sedimentation and the supernatant was used for further analysis.

2.4. Estimation of COD and MPN

Chemical Oxygen Demand was determined following the official method mentioned in APHA (2005). Detection of MPN **(**Total coliform using most probable number). In determining the most probable number of coliforms that were present in each of the treated water samples, the multiple tube fermentation method was adopted. Lactose broth was used as the medium for the bacteria growth. Two types of the Mac Konky broth were prepared. These were the single strength broth (SSMB) and the double strength lactose broths (DSMB) of three tube method were followed.

2.5. FT/IR analysis

The extracted samples were subjected to spectroscopic analysis - FT-IR using standard procedures at STIC, CUSAT, Cochin.

3. RESULTS AND DISCUSSION

The initial coliform content was highest with MPN as 1390±1.27 which got moderately reduced to 965±0.63 on 20 mg/l alum treatment. On increasing the alum treatment to 30 mg/l, the coliform count was decreased to 475±0.49(Table 1.) On evaluating the effect of alum treatment on COD of the treated sample it was observed that the COD was not much affected by alum treatment. The initial COD of the water sample was 19±0.35 mg/l which remained at 21±0.282 on 20 mg/l alum treatment. Even at 30 mg/l concentration of alum treatment the COD remained almost constant at 23±0.12 mg/l.

Table 1. Effect of Alum treatment on MPN and COD of Pamba river water

Trial	Alum Dosage (mg/l)	MPN	COD mg/l
1	0.0	1390±1.27	19±0.35
2	5.0	1295±1.06	120±0.04
3	10.0	1170±0.98	21±0.042
4	15.0	995±0.35	21±0.35
5	20.0	965±0.63	21±0.282
6	30.0	475±0.49	23±0.12

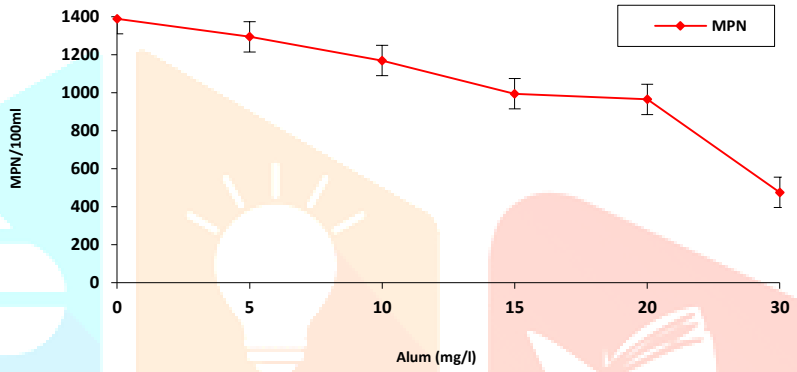

Figure 1. Effect of Alum treatment on MPN of Pamba river water

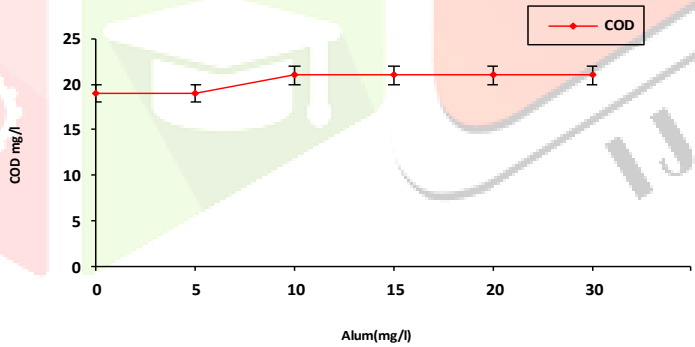

Figure 2. Effect of Alum treatment on COD of Pamba river water

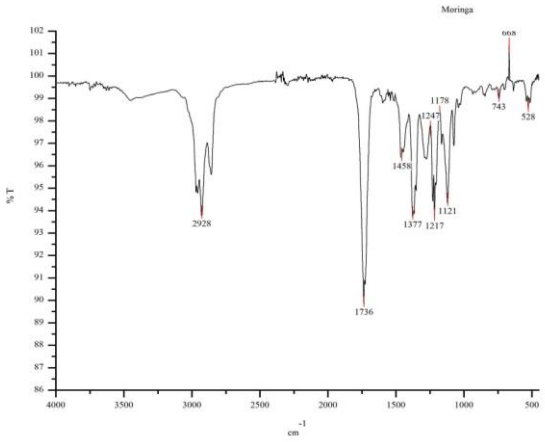

Figure 3. FT/IR spectrum of Pamba river water sample (untreated)

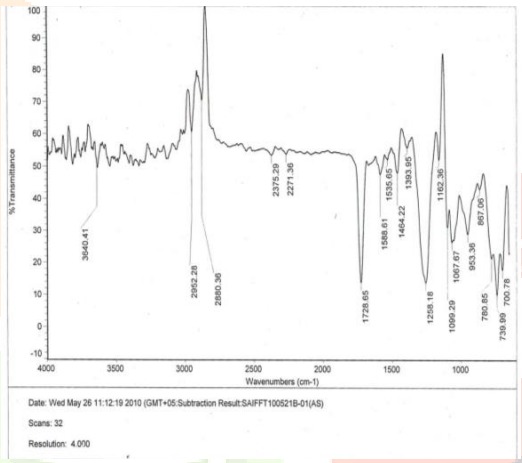

Figure 4. FT/IR of the ether extracted Pamba river water sample before chlorination

Subsequent FT/IR analyses of the samples were done to confirm the functional groups and the structure of the compounds within the sample. (Fig. 2 to Fig. 4).

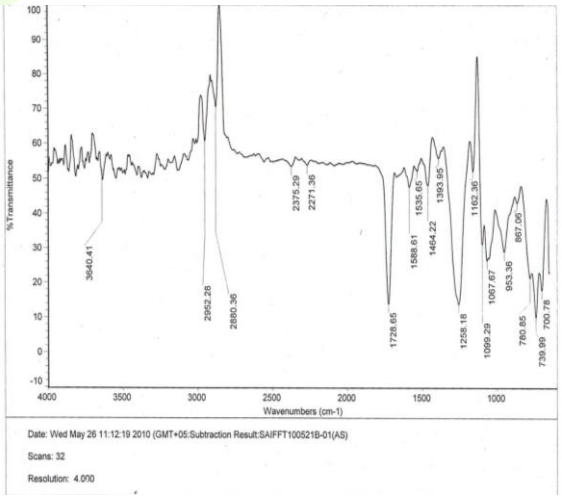

Figure 5. FT/IR of the ether extracted Pamba river water sample after chlorination

In the Fig. 5 band at 2880 cm^{-1} indicated Aliphatic CH_2, and at 1258 cm^{-1} indicated CH_2, band at 1100 cm^{-1} indicated C Cl bond and band at 700 cm^{-1} indicated the presence of residual chlorine Cl^-.

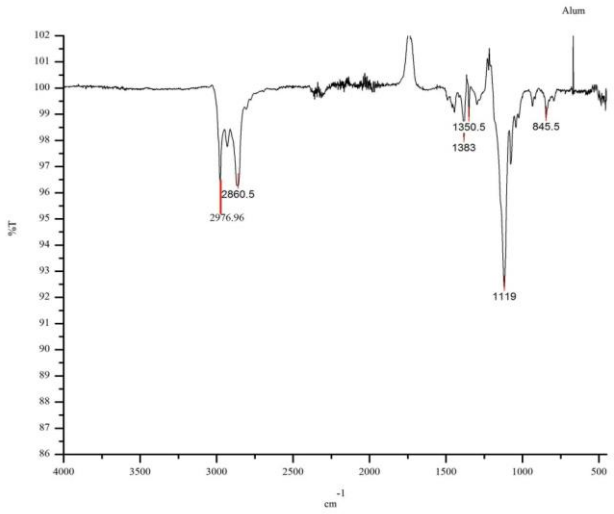

Figure 6. FT/IR spectrum of Pamba river water sample treated with Alum

In the FT/IR analysis of the Alum treated sample Fig. 6 shows that there is no such band at 2880 cm^{-1} , 1258 cm^{-1} , 1100 cm^{-1} 700 cm^{-1} , indicated Aliphatic CH_2, CH_2, C Cl bond Cl^-.

The Pamba river water is heavily polluted with respect to high coliform and suspended solids. The MPN test had shown consistently positive result which indicated the water samples as fecal contaminated and not safe for drinking. The Most Probable Number (MPN) representing total coli forms were extremely high and represented heavy fecal contamination. Fecal contamination of water leads to higher bacteria load and subsequent water-borne diseases. The selected indicator organisms like coliform bacteria, after having routinely monitored, helped to indicate the probability of pathogenic population in water that make it unsuitable for human consumption (Triebskorn *et al*., 2002, Sharma and Sarang, 2014). Joshua *et al* (2014) suggested that coliform groups have different associations with diarrhea in household drinking water. Their results supported the use of EC as a fecal indicator in household drinking water.

Equally, the water sample carried high value for the suspended solids which on the other side enhanced the polluting load of the sample. The removal of the suspended solids is generally regarded as the primary requisite for effectively treating any contaminated water systems. The most convenient and effective method of suspended solids removal is by sedimentation. It is based on the difference in the density between the bulk of the liquid and the sold particles. The settling may be discrete settling or zone settling. It may be by induced coagulation or by flocculation with flocculent aids. The coagulation or flocculation mediated sedimentation facilitates better sedimentation of the suspended matter resulting the co precipitation of coliform.

Studies by different researches questioned the benefits of chlorination against the deleterious effect that arises from chlorine residuals and from the byproducts of chlorination. A large number of studies have focused on the soluble volatile organic content of chlorinated and non-chlorinated waste waters using analytical techniques like GC/MS rather than BOD and COD (Jolley, 1975, Glaze and Henderson, 1975). Common inhabitants of intestinal tract, i.e., Bacteroides, Arcobacter and Clostridium, were found to survive chlorination and constitute the main microbiota detected in the disinfected effluent (Zerva et al 2021). According to Nada Al-Jassim (2015) a culture-based approach revealed that Pseudomonas aeruginosa was mainly found in the influent and non-chlorinated effluent but was replaced by other Pseudomonas spp. in

the chlorinated effluent. The study by Jannie Munk Kristensen *et al* (2020) also showed that culture-based analyses are insufficient for proper effluent quality control, and new standardized culture-independent measurements of effluent quality encompassing most pathogens should be considered.

The FT/IR data of the chlorinated samples gave strong evidence for the presence of new C-Cl bonds in alkanes being represented by the bands in the region of 2880 cm^{-1}, 1288 cm^{-1}, 1100 cm^{-1} and 700 cm^{-1}. The analysis of the three samples could bring sufficiently consistent representation regarding the presence of chlorinated alkanes.

4. CONCLUSION

Alum treatment of contaminated water is an age-old process and extensively used in the treatment of contaminated water with high amount of suspended solids. Alum acts as an effective coagulant and often results in the neutralization of charges surrounding the suspended solids. The neutralized solids get precipitated and sedimented along with the coliforms. However, alum treatment resulted only in the moderate removal of coliform which was totally insufficient. Also, the effect on COD was only moderate enhancing it from 19 mg/l to 23 mg/l. Alum itself is a chemical and any foreign chemical added to water is sure to make a modification in its organic nature. Even though alum treatment is globally accepted for water treatment in the primary stage ample scope is there for finding out a suitable alternative for the same

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