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Physicochemical Analysis of Seafood Processing Effluents in Aroor Gramapanchayath, Kerala

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Abstract : *Processing effluents from seafood processing industries are the major cause of water pollution in and around Aroor gramapanchayath, Alappuzha District. It creates adverse impacts on poorly flushed receiving water bodies. The present study represents the characterization of effluents from seafood processing industries in these areas. Effluent samples were collected from different processing sites and periodic physicochemical analysis were carried out to assess the quality of effluent. The important parameters such as pH, TS, TSS, alkalinity, ammonia, chloride, BOD and COD have been studied using standard protocol APHA. The physicochemical analysis reveals that all the samples are highly organic in nature and are highly polluted and can affect the aquatic ecosystem if it is released without adequate treatment.*

Keywords - *aquatic ecosystem, effluent, organic, physicochemical parameters, pollution.*

I. Introduction

Global production of fish and shrimp has been showing a steady increasing trend over the last decade and this trend is expected to continue[1]. Four panchayaths of Alappuzha District were declared first in the country as town of export excellence in the marine sector are Aroor, Ezhupunna, Kodamthuruth and Kuthiathodu in Cherthala Thaluk. Spread over 45 km^2, this continuous coastal strip which accounts for Rs.650 crore of the country's over 6,000 crore marine exports has 47 processing plants (of which 31 are approved by the European Union) two large cold storages, 130 ice plants, 175 pre-processing centers and several unregistered house peeling practices. Regarding water supply, it is estimated that in this area, the daily consumption by these fish processing sector is around 35 Lakh litres.

Various studies have been carried on the characterization of the processed products as well as the different possible modes of utilization of fish [2 - 4] and shrimp [5 - 11] processing by-products. Whereas the wastewater generated from seafood processing industries, the waste load as well as the role of wastes in the environment have not been received enough studies since long. Characterization of the seafood processing wastewater is important not only for the protection of ecosystem, but also for the sustainability of the fishery itself.

Seafood processing operations generate a high strength wastewater, which contain organic pollutants in soluble, colloidal and particulate form. Depending on the type of operation, the degree of contamination may vary from small, mild or heavy for example, washing operations, fish filleting and blood water drained from storage tanks respectively. A good part of this being drained off without adequate treatment, which ultimately reaches the water bodies. This contributes significantly to the suspended solid concentration of the waste stream, which leads to serious ecological problems. It is difficult to generalize the extent of the problem created by the wastewater as it depends on the effluent strength, wastewater discharge rate and the absorbing capacity of the receiving water body [12].

Various devastating ecological effects and human disasters in the last 40 years have arisen majorly from industrial wastes causing environmental degradation [13, 14] Recently, there has been an alarming and worrisome increase in organic pollutants [15]. The waste water discharge from industries are major source of pollution and affect the ecosystem [16]. Similar to most food processing industries, effluents from fish and crustacean processing plants are generally characterized by high concentrations of nutrients, high levels of nitrogen content as ammonia (NH_3-N; 29 to 35 $mg \cdot L^{-1}$), high total suspended solids (0.26 to 125,000 $mg \cdot L^{-1}$), increased biological oxygen demand (10 to 110,000 $mg \cdot L^{-1}$) and chemical oxygen demand (496 to 140,000 $mg \cdot L^{-1}$), and by the presence of sanitizers [17]. Several techniques are used for treatment of waste water from fish and surumi industries[18] . This study is aimed to characterize the physicochemical parameters of effluent discharged from seafood processing facilities.

II. Materials and methods

The selected area for this study was four seafood processing plants, where different types of seafood items are processed and effluent samples were collected from these sites with the help of clean plastic containers, washed with nonionic detergent, rinsed with tap water and finally washed with distilled water prior to usage. Carefully avoided the contamination of samples with any foreign materials while collecting. The samples were designated as sample A (Shrimp pre processing effluent), sample B (Cephalopod pre processing effluent), sample C (Fish filleting effluent) , and sample D (processing effluent). Samples collected were brought to the laboratory and preserved under 4^0C temperature. The samples were analyzed periodically for six months. Selected physicochemical parameters such as pH, Total Solids (TS), Total Suspended Solids (TSS), Alkalinity, Ammonia (NH_3-N), Chloride (Cl-), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were analyzed [19].

III. Results and discussion

3.1 pH

pH serve as one of the important parameters because it may reveal contamination of a wastewater body or indicate the need for pH adjustment for biological treatment of the wastewater. Average pH was 7.5 in both samples C and D, 7.4 in sample B and 6.8 in sample A. Variation in pH values of effluent can affect the rate of biological reactions and survival of various microorganisms. Generally, pH of seafood effluents are close to neutral . For example, a study found that the average pH of effluents from blue crab processing industries was 7.63, with a standard deviation of 0.54; for non-Alaska bottom fish, it was about 6.89 with a standard deviation of 0.69 [20]. The pH levels generally reflect the decomposition of proteinaceous matter and emission of ammonia compounds.

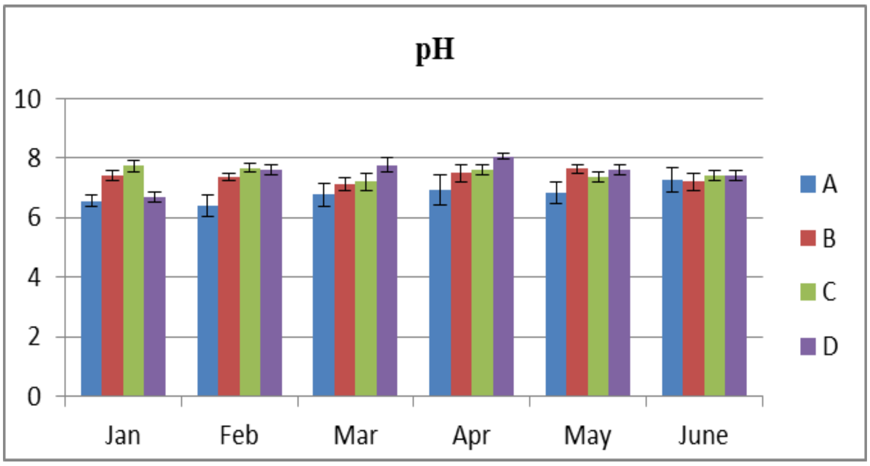

Fig. 1 Variation of pH in Prawn (A) and Cephalopod (B) pre-processing, Fish filleting (C) and Prawn processing (D) effluents.

3.2 Total Solids

Waste water contains variety of solid materials. Total solids are determined as residue left after evaporation of unfiltered samples. These wastes contribute significantly to the suspended solid concentration of the waste stream. There is a significant variation between different samples studied . The highest value was observed in Sample A, where it varied from1203 mg/L in the month of June to the highest 6754mg/L in April. By contrast the least amount was observed in the processing effluent where it varied from 1800mg/L to 2905 mg/L. The overall mean value for six months in sample A is 3779.9mg/L, in sample B is 3035.9 mg/L, in sample C is 2366.6 mg/L and in sample D is 2211.5 mg/L [21] found total solid 1310 mg/L in effluent in dairy industry.

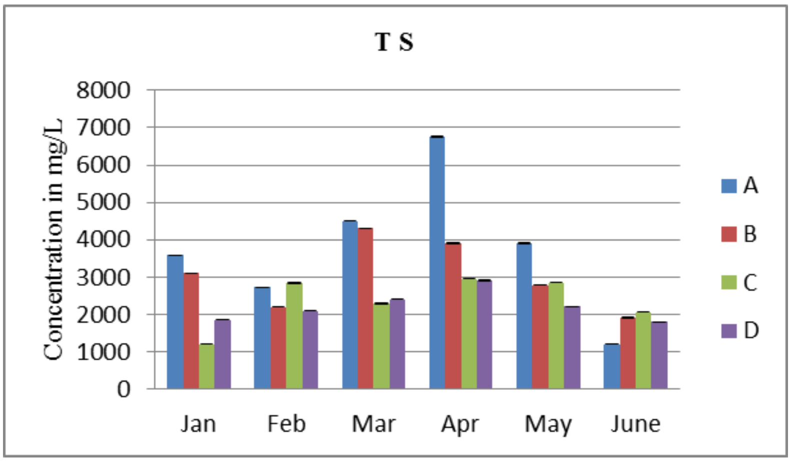

Fig. 2 Variation of TS in Prawn (A) and Cephalopod (B) pre-processing, Fish filleting (C) and Prawn processing (D) effluents.

1.3 Total Suspended Solids

Total suspended solids play an important role in waste water treatment. TSS test results are routinely used to assess the performance of conventional treatment processes and need for effluent filtration in reuse application. TSS are the samples under suspension and remains in effluent sample. In present study, the mean value in the pre- processing effluent fluctuates between 214 mg/L to 947.6 mg/L, where as in the processing plant effluent it varies from 79 mg/L to 328 mg/L in June. In cuttlefish cleaning effluent it varied from 124.9 mg/L in June to 644 mg/L in March, where as it is comparatively low in fish filleting effluent. The overall mean value for six months in sample A is 680.8 mg/L, in sample B is 355.9 mg/L, in sample C is 125.6 mg/L and in sample D is 191.5 mg/L [22] observed the T.S.S. of sugar mill effluents as 220 to 790 mg/L.

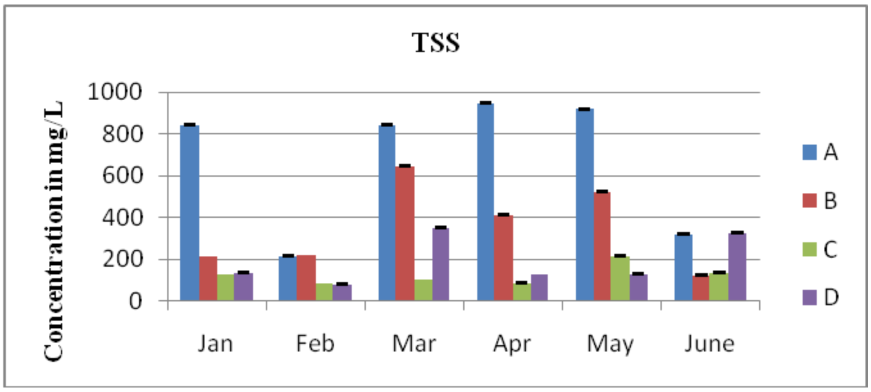

Fig. 3 Variation of TSS in Prawn (A) and Cephalopod (B) pre-processing, Fish filleting (C) and Prawn processing (D) effluents

3.4 Ammoniacal Nitrogen (NH3-N)

Sometimes high ammonia concentration is observed due to high blood and slime content in wastewater streams. The overall ammonia concentration is ranged from 0.7mg/L to 69.7mg/L [23]. The degree of ammonia toxicity depends primarily on the total ammonia concentration and pH. The NH3-N value was too high in all the samples analyzed in the month of March**,** to other months with 57.8 (Sample A), 43.6 (Sample B), 36.2 (Sample C) and 52.5 mg/L in (Sample D) respectively. However, it is predominantly high in all the months in sample A and sample D. The overall mean value for six months in sample A is 36.1mg/L, in sample B is 32.6 mg/L, in sample C is 29.1 mg/L and in sample D is 36.2 mg/L.

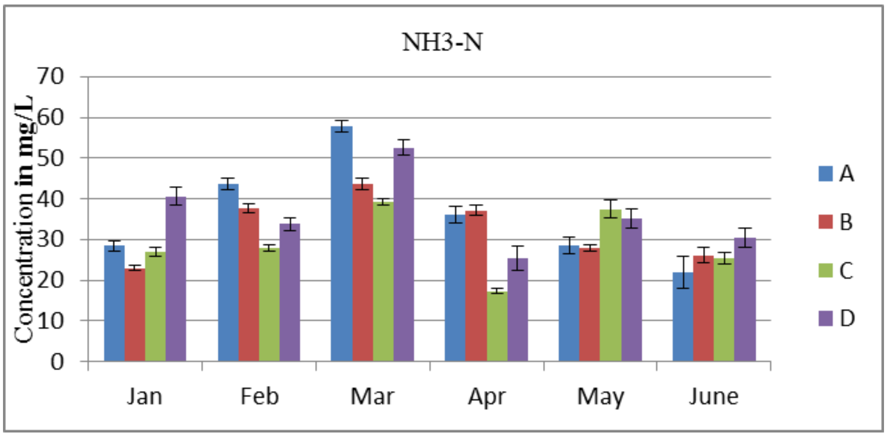

Fig. 4 Variation of NH3-N in Prawn (A) and Cephalopod (B) pre-processing, Fish filleting (C) and Prawn processing (D) effluents.

3.5 Oil and Grease (O & G) :

The highest value observed is 12.25 mg/L in sample C, where it varied from 2.1 mg/L to 12.25 mg/L, at the same time in sample A the value varied between 1.6 to 6.8 mg/L, and in sample B it varied from 1.7 mg/L to 3.7 mg/L. however it is considerably less in sample D, where it varied from 0.06 to 1.92 mg/L. The mean value together for all the six months, in sample A is 4 mg/L, sample B is 2.9 mg/L, sample C is 5.1 mg/L, and in sample D is 0.9 mg/L.

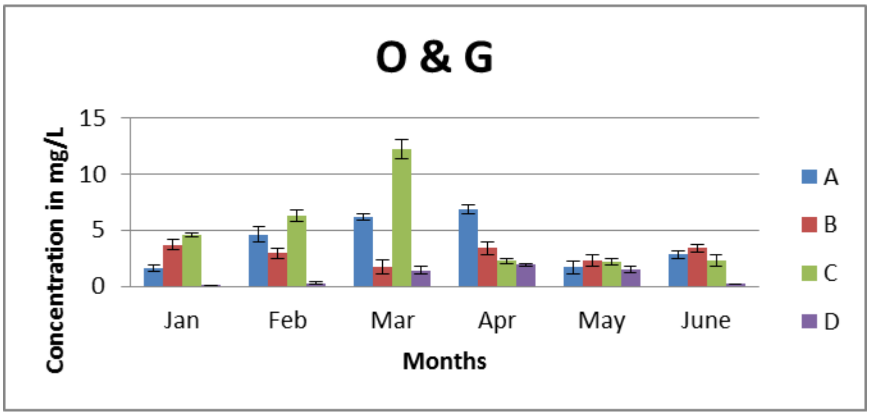

Fig. 5 Variation of O & G in Prawn (A) and Cephalopod (B) pre-processing, Fish filleting (C) and Prawn processing (D) effluents

3.6 Biological Oxygen Demand (BOD) :

Biochemical oxygen demand (BOD) estimates the degree of contamination by measuring the oxygen required for oxidation of organic matter by aerobic metabolism of the microbial flora. It is also taken as a measure of the concentration of organic matter present in any water. The greater the decomposable matter present, the greater the oxygen demand and the greater the BOD values [24]. In seafood-processing effluent biological oxygen demand originates from the carbonaceous compounds which are used by microorganisms as their substrate and from the nitrogenous compounds such as proteins and volatile amines. Wastewaters from seafood-processing operations can be very high in BOD_5. BOD values of sample D is fairly low compared with the sample A. In sample D it varies from 560 mg/L to 1226.6 mg/L, whereas in sample A it ranges from 1266 mg/L to 3600 mg/L. In sample B, it varies from 1466 mg/L to 3166.6 mg/L, while in sample C it ranges from 920 mg/L to 1635 mg/L. Overall mean value for six months together in sample A is 2250 mg/l, sample B is 2061 mg/l , in sample C is 1342 mg/L and in sample D is 964 mg/L. Low value of BOD is may be due to lesser quantity of total solids, suspended solids in water as well as to the quantitative number of microbial population [22].

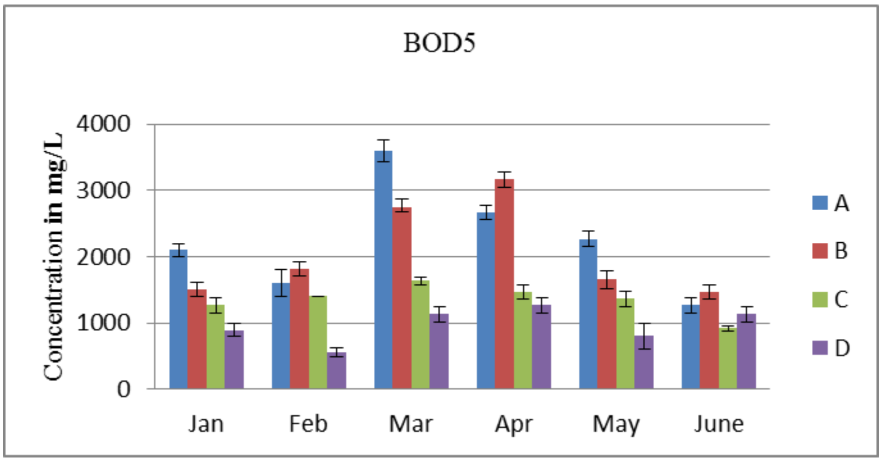

Fig. 6 Variation of BOD in Prawn (A) and Cephalopod (B) pre-processing, Fish filleting (C) and Prawn processing (D) effluents

3.7 Chemical Oxygen Demand (COD)

The COD is a test which is used to measure pollution of domestic and industrial waste. The waste is measured by the amount of oxygen required for oxidation of organic matter to produce CO2 and water. COD of an effluent is usually higher than the BOD5, because the number of compounds that can be chemically oxidized is greater than those that can be degraded biologically. Due to rapid change in salinity soluble COD was increased by the release of cellular material [25] In present study COD in sample A ranges from 1666 mg/L to 3666 mg/L, by contrast in sample D it varies from 800 mg/L to 1666 mg/L. In sample B it varies from 2066 mg/L to 3164 mg/L, and in sample C it varies from 1500 mg/L to 2660 mg/L. The overall mean value for six months in sample A is 2700 mg/L, in sample B is 2570 mg/L, in sample C is 1882 mg/l, and in sample D is 1442 mg/L. If these effluents are released into the water body without adequate treatment, it may affect the aquatic ecosystem. Seafood processing effluents are primarily organic in nature and therefore subject to bacterial decay. As a result, the oxygen concentration in the water is reduced with an increase in BOD. This can deprive aquatic life of oxygen it needs and anaerobic decomposition of organic matters lead to the breakdown of proteins and other nitrogenous compounds, releasing hydrogen sulphide, ammonia and methane, all of which are potentially hazardous to the ecosystem and toxic to aquatic organisms in low concentrations. Nutrients resulting from decaying organic matter enhance plant growth together with oxygen depletion can lead to alterations in ecosystem structure and these are both features of eutrophication.

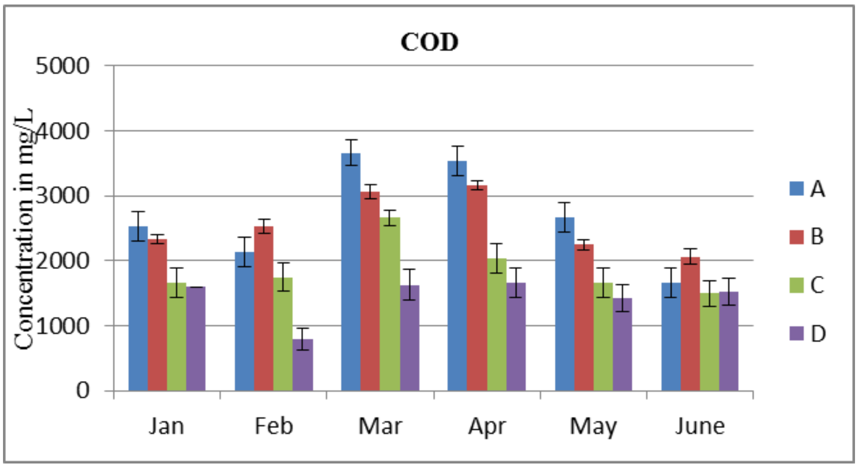

Fig. 7 Variation of COD in Prawn (A) and Cephalopod (B) pre-processing, Fish filleting (C) and Prawn processing (D) effluents

3.8 Chloride

Chloride content is more in fish processing effluent, as salt is used for preservation and the highest mean value observed in sample C is 1010 mg/L, while it is predominantly high in sample D in all the months analyzed. The summative mean value for six months in sample A is 800 mg/L, in sample B is 809.7 mg/L, in sample C is 838 mg/L , and in sample D is 875 mg/L. Chloride of untreated effluent in dairy industry is observed as 630 mg/L [26]. Effluent from sugar mill showed 205 mg/L chloride content [27].

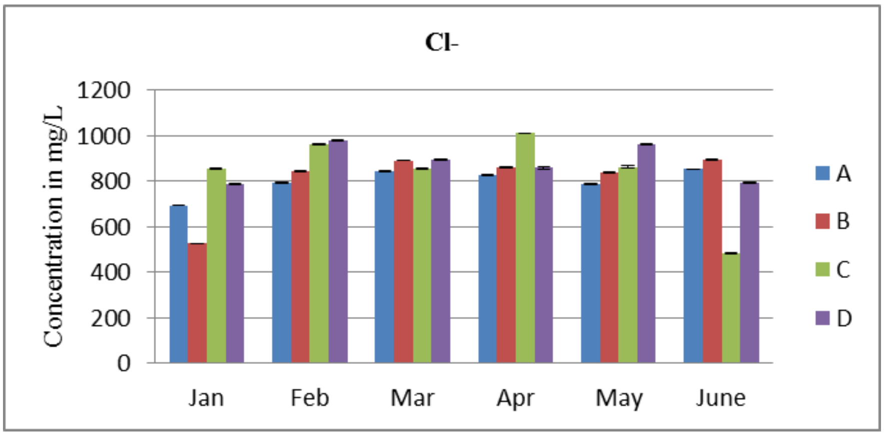

Fig. 8 Variation of Cl- in Prawn (A) and Cephalopod (B) pre-processing, Fish filleting (C) and Prawn processing (D) effluents

3.9 Alkalinity

Alkalinity of water is its acid-neutralizing capacity. It is the sum of all the titrable bases. The measured value may vary significantly with the end-point pH used. Alkalinity measurements are used in the interpretation and control of water and wastewater treatment processes. The highest value recorded was in sample B with a figure of 796 mg/L and the least was in sample A 324 mg/L. The mean value together for six months in sample A is 410 mg/L, in sample B is 555.3 mg/L, in sample C is 486 mg/L and in sample D is 505.5 mg/L.

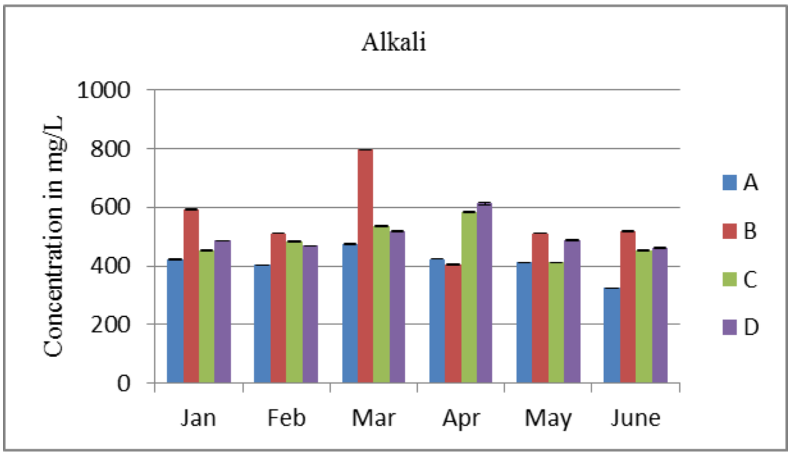

Fig. 9 Variation of Alkali in Prawn (A) and Cephalopod (B) pre-processing, Fish filleting (C) and Prawn processing (D) effluents

IV. Conclusion

It is clear that these industries release heavy loads of organic wastes and are discharged into the nearby water bodies through discharge channels and are potentially hazardous to the receiving environments. In addition to that, too many processing plants are clustered in one area will ultimately overwhelm the natural ecosystems nearby, leads to unnecessary fertilization and eutrophication of the surrounding water bodies. There are obvious impacts, because of these wastes as it produces year round, giving no chance for the environment to recover. Moreover, these impacts are more detrimental, when the same ecosystem receives wastes from cluster of processing industries. The overall findings reveals that the effluents from fish processing industries are highly polluted and remedial steps should be taken to avoiding water pollution and thereby environmental pollution.

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