SUMMARY

1. **Treatment of domestic sewage** - Aquaculture process of domestic sewage treatment using waterhyacinth and algae was studied.

Waterhyacinth plants grown in sewage water was found to exhibit remarkable ability to purify sewage water. These plants reduced not only the biological oxygen demand of wastewater but also inorganic nutrients like ammonia and phosphates from such water appreciably.

The water treated by waterhyacinth alone, however, was deficient in dissolved oxygen and supported scarce animal lives. If sufficient retention time was not allowed, there might even be emission of foul smell from such water. A stage for culturing algae in this water was, therefore, incorporated.

The purifying capacity of algae culture was found to be appreciable. The algae culture stage along with the first waterhyacinth culture was found to have caused an overall improvement of water quality regarding a reduction of B.O.D. by 86-94%, ammoniacal-nitrogen by 79-90%, phosphate as P by 67-87% and coliform count by 96-97%. The growth and multiplication of algae increased the dissolved oxygen concentration of water leading to the increase in the number of phytoplanktons from 640-912/ml. to 16970-
27252 cells/ml. Due to increase of phytoplanktons the zooplanktons invariably increased from 100-218 to 5763-6994 organisms/litre. The water at the outlet of algae culture was of much improved quality with respect to B.O.D., turbidity, inorganic nitrogen, phosphates, coliform bacteria, pH, dissolved oxygen and zooplanktons. But the higher contents of suspended solids mainly due to algae cells made this water unfit for discharge in the natural bodies of water. The water with algae cells as suspended solids was, therefore, further treated in a second waterhyacinth culture mainly for the removal of the suspended solids. The culture of waterhyacinth plant was found to help settle the algae cells at the bottom of the culturing tank leaving the supernatant visibly clean and transparent. The water was no longer green as more than 89% of algae cells have been removed.

As a result of this three stage aquaculture treatment of domestic sewage an overall reduction of 96% of B.O.D., 96% of ammonia-Nitrogen, 90% of Phosphate as P and 99% of coliform bacteria were achieved during a total retention time of 15.5 days. The process was thus capable of producing water of sufficient good quality and the treated water seemed to be quite productive in nature as the population of zooplanktons which could be used by fish as their food was quite high (10925 organisms/litre) at the discharge point.
During the process of sewage treatment by aquaculture, 68.26 and 50.1 tons/ha/yr. of dry organic mass (waterhyacinth) were harvested during the summer months from the waterhyacinth culture-1 and culture-2 respectively. The yields obtained during the winter months were somewhat less (46-49 tons/ha/yr). This indicated that lower temperature exerted some inhibitory effects on the growth potentiality of waterhyacinth plants. The harvested organic mass, however, could be utilised for the production of biogas and organic manure.

In the first series of experiments the sewage water was charged directly to the waterhyacinth culture-1 with the intention of recovering nutrients in the form of harvested plants. Though a very good amount of harvested mass was obtained, the process often led to the development of offensive smell specially with lower retention period of treatment.

In the second sets of experiments, the settled sewage was charged directly to the algae culture trough. This treatment after 8 days retention time reduced B.O.D. by 92.46%, ammoniacal-nitrogen by 94.58%, phosphate as P by 90.30% and coliform bacteria by 92.9%. The average number of phytoplanktons and zooplanktons were 67040 cells/ml. and 3549 organisms/litre respectively.
The water at the outlet of algae culture trough was dark green in color. The water was then charged to a waterhyacinth culture tank. This step caused a substantial reduction (about 97.7%) of phytoplanktons making the water quite clean. This reduction of phytoplanktons was accompanied by a spectacular increase of zooplanktons noted at the discharge points.

A comparison of results obtained by the two sets of experiments revealed that a two stage treatment of sewage by algae culture with 4 days retention time followed by a waterhyacinth culture for another 4 days was sufficient enough to remove most of the pollutants producing water of good quality but the recovery of nutrients in the form of organic mass was not adequate.

2. **Removal of nitrogen from fertiliser factory effluents by biological process of treatment** - Two biological processes were studied. In the first process, as was shown in the following flow diagram, urea was first biologically hydrolysed to ammonia and carbondioxide.

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\text{Effluent containing Urea} \xrightarrow{\text{hydrolysis}} \text{NH}_3 \xrightarrow{\text{hydrolysis}} \text{Algae culture} \xrightarrow{\text{NH}_3} \text{free water.}
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The degree of hydrolysis obtained depended on the B.O.D. load supplied the concentration of urea-present and the retention time given in the presence of adequate population of ureolytic bacteria.
The removal of ammonia was then achieved by culturing unicellular algae in the urea hydrolysate. During the growth of algae some ammonia were utilised as nutrients but a major part of the ammonia (about 92%) was lost through volatilisation as a result of high pH prevailing in the algae culture solution.

In the second process, microorganisms involved in the oxidation of ammonia to nitrates (Nitrification) and the reduction of nitrate to elemental nitrogen (denitrification) were cultured under laboratory conditions. It was evident from the results that the rate of nitrification was greatly influenced by the pH of the solution. Within the pH range of 8.4 - 8.02 the optimum conditions for nitrification started and consequently, the highest rate of alkalinity destruction and the loss of ammonia were achieved. At the optimum condition of nitrification it was possible to get about 49 mg/l/hr. of the oxidised nitrogen formed with the loss of equivalent amount of ammonia.

Apart from pH, the population of nitrifying organisms in the system were also found to influence the rate of nitrification. The well aerated activated sludge measured as the mixed liquor suspended solids (MLSS) was used as the source of nitrifying organisms. The rate of nitrification was found to go on increasing with
the increase of MLSS from 241.5 to 685.78 mg/lit. Any further increase of this, however, did not cause further change.

The loss in the oxidised nitrogen by the denitrification process was also studied under laboratory conditions. The bacterial sludge was obtained by composting cow dung mixed with the garden soil. Some experiments were conducted with methanol and molasses as feed for the bacteria. It was noted that by adding 1 ml. of methanol/litre yielding a B.O.D. load of 775 mg/lit., about 88.9% loss of the oxidised nitrogen could be achieved in 24 hours. The ratio of the oxidised nitrogen lost to the B.O.D. supplied was found to be 1:1-8. With molasses, 82% and 98.2%, the loss in the oxidised nitrogen were obtained by supplying a B.O.D. load of 1350 and 1620 mg/lit. respectively during the same period of incubation. The ratio of the oxidised-nitrogen lost to the B.O.D. supplied by molasses was 1:3.5. Thus methanol seemed to be the most effective substrate for denitrification as it was capable of removing about the same amount of the oxidised nitrogen from the system by supplying about half the load of B.O.D. than that required if molasses were used as the substrate.