SUMMARY

Three series of experiments were carried out with three different algal forms to study : (a) the degree of purification in terms of organic matter removal and nutrients removal; (b) the amount of algal biomass production, (c) a quantitative evaluation of "algal bacterial symbiosis" and (d) correlation between algal biomass formed and COD used up. In the first series of experiment the alga used was Nostoc pyriformis; in the second, Anabaena cylindrica and in the third mixed algae consisting of Chlorella vulgaris, Scenedesmus obliqus, Oscillatoria chalybea and Oscillatoria obscura in almost equal proportions. In the first two series of experiments tests were made only for physico-chemical conditions on zero, second, fourth and sixth day of detention; while in the third series of experiment dealing with the mixed algae, tests were made for physico-chemical, biochemical and biological conditions on zero, second, fourth and sixth day of detention period. Controls were also studied in each case.

No appreciable changes in pH, colour, alkalinity and amounts of ammonia nitrogen, nitrate nitrogen,

nitrite-nitrogen and phosphate-phosphorus were found in the control flasks. They showed about 60 to 70% reduction in COD and BOD_5 values. This has to be attributed to the phenomena of mechanical flocculation, bioflocculation and bioprecipitation which are of common occurrence in nature and to comparatively slower surface reaeration phenomenon. In all the algal flasks also, no appreciable changes were found in the amounts of nitrate and nitrite nitrogen. But, colour changed to bluish green in the case of Nostoc and Anabaena and predominantly greenish in case of the mixed algae. pH increased from second day onwards to about 10 in all the cultures. The increase has to be attributed mainly to phenolphthalein alkalinity resulting from photosynthetic activities of the algae. In all the three algal cultures studied, the reduction in ammonia-nitrogen varied between 73 to 78% within two days and between 90 to 94% within six days indicating that ammonia-nitrogen and phosphorus seem to be utilized chiefly as nutrients for algal growth.

Further, in all the three algal cultures studied the reduction in BOD_5 varied between 58 to 72% within two days and 87 to 92% within six days; while the reduction in COD varied between 62 to 72% within two days and between 85 to 93% within six days. The comparatively greater percentage reductions in BOD_5 and COD in the algal flasks have to be ascribed to photosynthetic oxygen furnished quickly to bacteria as a result of algal photosynthesis.

Again, the control flasks showed 66% reduction in protein, 81% reduction in amino acid nitrogen, 64% reduction in total sugar, 77% reduction in free sugar and 82% reduction in volatile acids within six days; while the algal flasks containing the mixed algae showed 77% reduction in protein, 88% reduction in amino acid nitrogen, 81% reduction in total sugar, 90% reduction in free sugar and 94% reduction in volatile acids within six days. The reduction of these biochemical variables in the control has to be attributed to metabolic activities of bacteria. Surface aeration, a comparatively slower process, has helped in providing oxygen to bacteria for degradation of the organic matter constituents. But the higher percentage of reduction in the algal flasks has to be attributed to the greater and quicker availability of photosynthetic oxygen.

Besides, flocculent brown precipitates were separately seen at the bottom only in the control flasks, while organic debris was observed intermixed with algae in the algal culture (mixed algae). Lecane sp. was found as an indicator of purification (mixed algae). Algal dry weights in all the algal flasks varied between 199 to 208 mg within two days and between 205 to 218 mg within six days.

Most of the physico-chemical variables such as ammonia nitrogen, phosphate phosphorus, BOD_5, and COD were used up and algal biomass was formed to a very great extent during first two days of the assimilatory phase and much less quantities were used during the last four days of the endogenous phase. But the biochemical variables such as protein, amino acid nitrogen, free sugar, total sugar and volatile acids were used up to a great extent during the first four days of the assimilatory phase and much less quantities were used during the last two days of the endogenous phase. These results seem to be intriguing and require further work.

The total bacterial biomass calculated according to Sawyer is about 50 to 60% of the corresponding values calculated according to McKinney and McKinney's values are nearly one half of the corresponding values for algal biomass. In other words, the algal biomass works out to be nearly twice the total bacterial biomass calculated according to McKinney.

The main metabolic reactions taking place in high-rate aerobic ponds is the "algal bacterial symbiosis" in the restricted sense. So the mechanism of "algal bacterial symbiosis" has been dissected for the first time into its two component parts : (a) bacterial oxidation and (b) algal photosynthesis with a view to assess quantitatively how one has helped the other in our three experiments by means of simple equations and certain assumptions based on well known facts. This is an important contribution to our knowledge on the subject of oxidation ponds.

Organic matter values were calculated by dividing the COD values obtained in the three experiments by 1.2 according to Porges (1960). The organic matter values thus obtained were multiplied respectively by 1.69 and by 1.56 according to Oswald et al.(1957) to calculate the quantities of carbon dioxide production and oxygen requirement for bio-oxidation of organic matter. Thus, during bacterial oxidation, 187 to 227 mg. of organic matter were oxidised by bacteria in six days and this was effected by 289 to 355 mg. of oxygen and as a result 213 to 384 mg. of carbon dioxide were released for the use by algae for algal photosynthesis.

Next, the algal dry biomasses estimated in the three experiments were multiplied by 1.8 according to Myers (1962) and by 1.6 according to Oswald and Gotaas (1957) to calculate carbon dioxide required and oxygen released respectively during algal photosynthesis. Thus, during algal photosynthesis, 369 to 392 mg. of carbon dioxide were fixed up in the formation of 205 to 218 mg. of algae releasing 328 to 349 mg. of photosynthetic oxygen in six days.

Thus, there was always an excess (13 to 17.6%) of photosynthetic oxygen produced over that required for bio-oxidation of sewage organic matter, so that the ecosystem was always kept under aerobic conditions. The quantities of carbon dioxide required for algal photosynthesis are 2 to 64% more than that released during bacterial oxidation. The excess carbon dioxide required for the algal biomass formation should have come from: (a) the atmosphere and bicarbonate-carbonate equilibrium system and (b) extracellular product, glycollate, released by algae during photosynthesis may also have been utilised by bacteria for carbon dioxide production (Fogg, 1971).

Next, a high degree of direct correlation between algal growths and their corresponding used up COD values is found and the correlation coefficient between these two ranges between +0.79 to +0.997. Photosynthetic efficiency ranged between 1.85 to 1.96%.

Nearly 92 to 94% ammonia-nitrogen have been utilized in the whole treatment process, but only about 45 to 50% of the influent nitrogen have been utilized by algae within six days for their growth. The rest must have been utilized for other biochemical reactions and/or lost to atmosphere. Similarly out of 71 to 97% phosphate phosphorus utilized in the treatment process only 33 to 44% of phosphorus has been utilized by algae within six days for their growth. The rest must have been precipitated on account of higher pH.

C:N ratios were found to be nearly same in both control and algal flasks, ranging respectively between 4.4 to 5.4:1 and 4.1 to 5.1 :1; while C:P and N:P ratios were found to be higher in the algal flasks. C:P and N:P ratios in the control flasks were found to be ranging between 9.5 to 10.1:1 and 1.9 to 2.1:1 respectively and in the algal flasks between 27.2 to 37.2:1 and 6.3 to 7.3:1 respectively.

"Total oxidation" de jure is not taking place in high-rate aerobic ponds, since some quantity of sludge accumulates. Total oxidation means absolute oxidation which includes complete oxidation, incomplete oxidation and endogenous respiration. But according to Washington and Hetling (1965) some inert mass corresponding to 10% COD consumed remains non-degradable. The algal biomass produced corresponding to this inert mass is 6 to 10% of the total biomass which may be considered insignificant.

Studies on catalase activity were also made to find out its relation to certain important waste water parameters like turbidity, BOD_5 and COD. Catalase against COD showed a maximum correlation of +0.80, against turbidity it was slightly less +0.78 and against BOD_5 it was least showing +0.53.

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