Ecological parameters in oxidation ponds

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Waste Stabilization Ponds are important for tropical countries like India. With their low initial cost and multiple benefits, they could be used with advantage in developing countries where availability of land is no problem. An ecological study of the ponds, with an eco-system approach, therefore becomes relevant.

In the present study it was found that the maximum production in pond is achieved between 0800 and 1100 Hours; the respiration is maximum in the afternoon reaching its lowest value in the morning corresponding to a minimum temperature. Minimum DO levels were recorded at around 0300 Hours, reaching near saturation value. The algae in the log phase of growth were found a shade faster than that in the decay phase in starting the production and reaching to its peak value. The pH of the pond waters were found to rise with production moving into alkaline range and as such it can be an index of productivity in an aquatic ecosystem.

INTRODUCTION

Waste Stabilization Ponds are semi-natural engineered ecosystem. Its low cost of construction, negligible recurring expenses, its freedom from mechanical equipment and skilled maintenance, as also the great potential it holds in utilization of its effluents for harvesting of protein-rich algae, pisciculture and irrigation usage etc., make it worthy of its popularity and almost a tailor-made proposition of waste treatment for a developing country with a tropical climate.

A waste stabilization pond is an excellent example of a small ecosystem having its own structural components - biotic and abiotic, as also the necessary functional components like energy circuits, food chains etc. The mechanism of treatment in waste stabilization pond is symbiotic i.e. mutualistic symbiosis exists between algae and aerobic bacteria as shown in Fig.1.

Considerable studies have been carried out on waste stabilization ponds, but mostly by engineers or botanists with one or other component in focus. An ecosystem approach to a waste stabilization pond has been lacking so far.

EXPERIMENTAL PROCEDURE

To study the variations in ecological parameters in a waste stabilization pond with varying BOD inputs, laboratory scale models, consisting of glass aquaria of size 45 cm x 30 cm x 30 cm deep with open top were taken. BOD inputs varying from 35 mg/L to 350 mg/L were taken and variations in Production (P), Respiration (R), pH, were recorded. Synthetic waste was prepared as suggested by Humeric and Hanna(1) and domestic waste was proportionately mixed for seeding and achieving desired BOD values. Standard Methods(2) was followed for physical and chemical examinations. P and R values were determined by Dark and Light Bottle

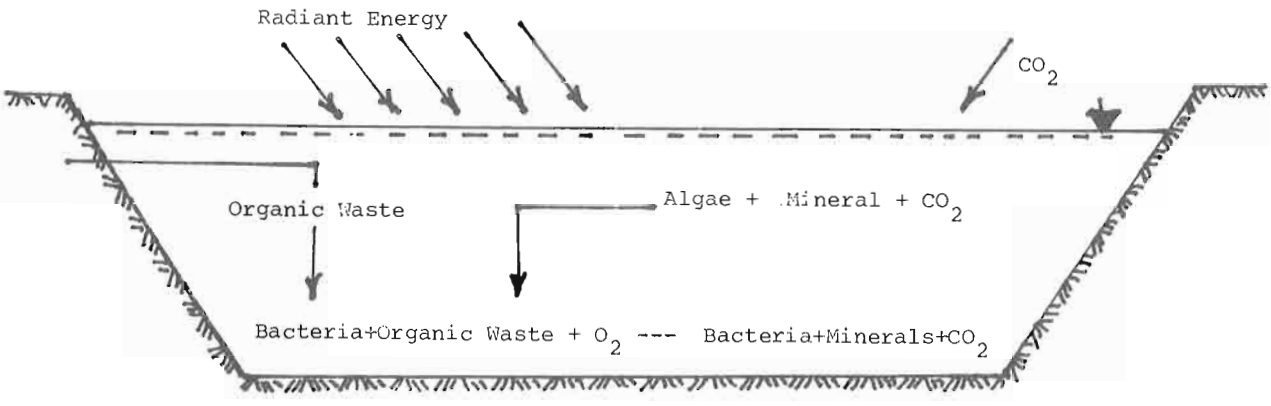

Fig.1 Algal-Bacteria Symbiosis in Waste Stabilization Pond

experiments. Diurnal studies were made on ponds in log phase as well as decline phase of the growth. The observations were recorded at every 3 Hour interval for a complete cycle of 24 Hours including the dark and light period. It would be well to keep in mind that values obtained for any ecological parameter at a certain hour, actually reflect the cumulative activity over the preceeding three hours.

The variations of pond DO and P have been plotted against time in Fig.2. The maximum DO concentration ranged from more than twice to more than four times the saturation levels. Also the peak DO concentrations declined with increase in BOD as also observed by Mackenthun et. al.(4). Minimum DO values were recorded at 0300 Hours in all the ponds reaching below saturation levels in old culture ponds, whereas in ponds with young culture DO levels never dipped below saturation. This appears to be due to reduction in photosynthetic efficiency with aging of algal cells.

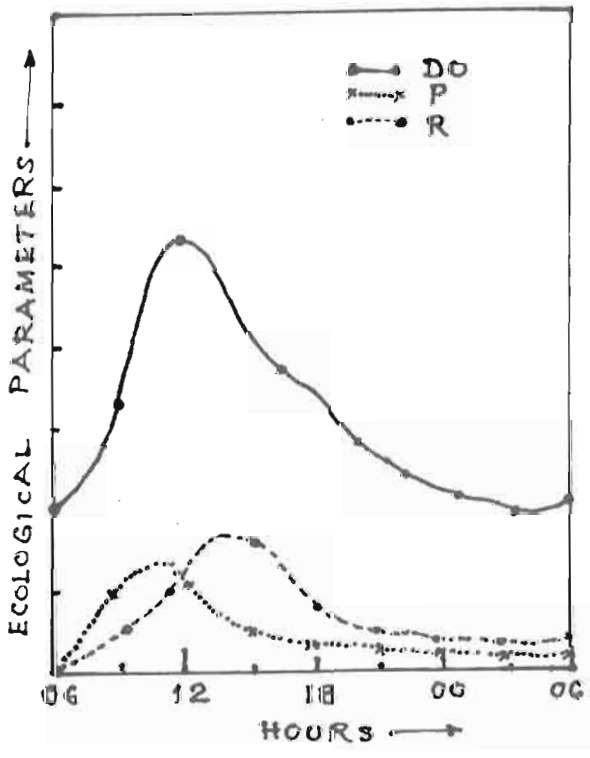

Fig.2 Variation of DO, Production and Respiration

The maximum production, P, was observed between 0800 to 1100 Hours. Apart from the right solar intensity and temperature, the rapid depletion of CO_2 appears to be the most likely cause of photosynthetic production. Bartsch(5) also reported the mid morning photosynthesis to be 50 percent greater than that in the mid-day. Strangley enough, production though greatly reduced during night hours, was never exactly zero, and all ponds had minima around 0300 Hours. The predominant algae in all these ponds was Chlorella Sp., which has been reported to be a versatile autotroph.

A study of diurnal variation of respiration, R, with time shows it to gradually increase in the morning, reach its maximum in the afternoon and decline all thrrugh the night touching a minimum at 0600 Hours. Respiration, R, has generally followed temperature in its diurnal variation.

Diurnal variations of pH has been shown plotted in Fig.3. As observed pH starts rising from the morning but highest pH levels are reached between 1500 to 1800 Hours, and remain above the mean value until after sunset. Similar results have been documented by Wilford et.al.(6). pH value depends upon CO_2 concentration in the medium, which, in turn, varies inversely with the rate of production, P. The maximum pH values are found to be lagging by 6 to 9 hours, reasons being the dark reactions continuing and utilizing CO_2 for cell synthesis even after sunset.

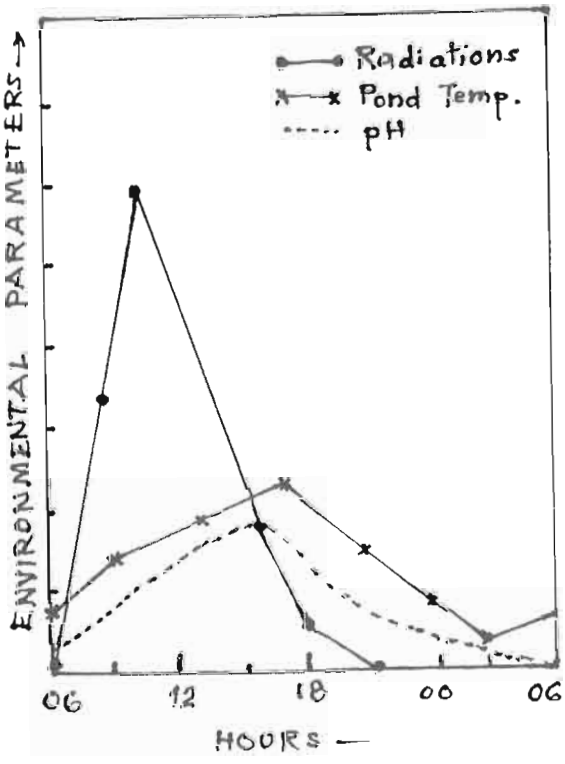

Fig.3 Variation of pH, Temperature and Solar Radiation

Further batch studies of daily variations of ecological parameters(Fig.4) revealed the DO concentration. Production and respiration followed characteristic growth pattern of algae and a distinct second peak, lower through, as comapred to the first peak. DO concentrations reached much higher than the saturation values, which are most undesirable from the ecological point of view. Not only that, part of this DO is lost to atmosphere, associated heavy algal growth results in extra BOD load on the ecosystem. Hence ecosystem approach for efficient and most consistent nutrient removal from waste stabilization pond advocates algal-harvesting.

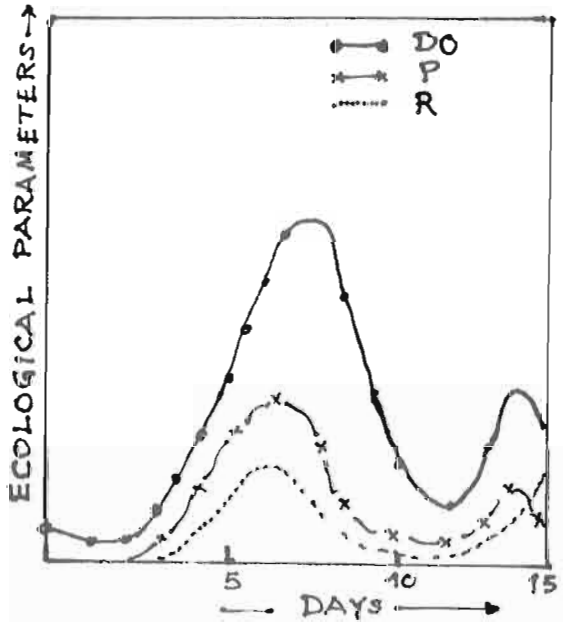

Fig.4 Daily Variation of Ecological Parameters

Fig.5 reveals that peak P values increase with increase in BOD inputs upto an optimum, then declines with further increase.It shows that the production initially increases upto an optimum nutrient concentration and further increase inhibits production due to toxic effect, less penetration of sunlight etc., explaining the failure of waste stabilization ponds with shock loadings.

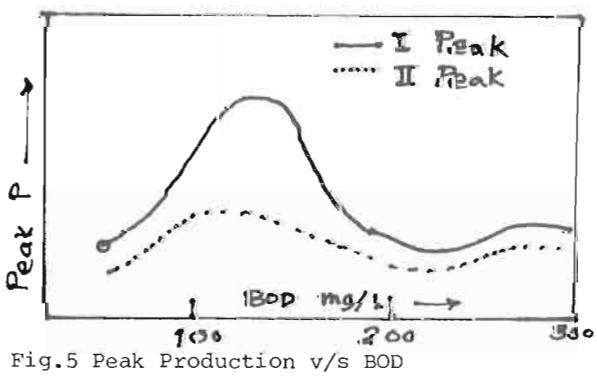

Fig.5 Peak Production v/s BOD

Respiration shows lag in occurrence of second peak and its magnitude. In fact in earlier stages both bacterial mass and algal cells extert their own respirational requirements resulting in general increase till both P and R reach their first peak almost simultaneously. Beyond this, with limiting nutrients, algal cells lead to sensescence and death, which do not produce but continue to respire. With decomposess continuing to respire on death algal cells, which have four times respiration needs than living, the respiration shoots up while production declines, thus introducing a lag in occurrence of second peak.

P/R ratio is an important factor in an aquatic ecosystem like waste stabilization pond. Higher P/R ratios are just as much undesirable as lesser ratios, the former showing excessive production indicating unnecessary BOD load on the system, and the latter showing oxygen hunger of the pond leading to anaerobic conditions. In an earlier study (7) a value of 2.26 gave maximum BOD removal efficiency, which was achieved in this study at a BOD loading of 114 mg/litre at second peak,and hence shall be taken as recommended loading for design of completely aerobic ponds at Roorkee.

CONCLUSIONS

From the present study of diurnal variations of ecological parameters in a WSP, the following conclusions are drawn:

a) The pond DO and production follow the light intensity closely. The maximum DO concentrations reached are two to four times the saturation levels.

b) Peak DO concentrations declined with increase in BOD value.

c) Minimum DO levels are recorded at 0300 Hours in all ponds. The concentrations never reached below saturation levels in young culture ponds, which are a shade faster in photosynthesis than the old cells.

d) Maximum production was observed between 0800 and 1100 Hours. Production though greatly reduced during night, never reached zero. The minimum was recorded at 0300 Hours. The predominant speci chlorella Sp. seems to be a versatile autotrouph.

e) Respiration recorded was maximum in the afternoon, reaching its lowest value at 0600 Hours in the morning, corresponding to minimum pond temperature. It

shows that respiration is a function of pond temperature also.

f) pH of the pond rises with production moving into the alkaline range and as such it can be an index of the productivity of the ecosystem.

The batch study of daily variations of the ecological parameter concludes that

i) the pond DO, production and respiration follow the general pattern of algal. The ecosystem tries to re-establish itself as shown by a second peak where algae too shows a secondary growth phenomenon.

ii) The peak production is a function of BOD inputs. It increases with increase BOD concentrations upto a maxima and declines with further increase. This explains the failure of ponds with shock loading.

iii) Harvesting of algae is essential from ecological point of view for efficient functioning of waste stabilization ponds.

ACKNOWLEDGEMENT

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