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SIGNIFICANCE OF OXIDATION PONDS IN SEMI ARID ENVIRON OF JAIPUR—A REVIEW

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Oxidation ponds in a semi-arid environment have been characterised, which include physical, chemical and biological factors. Physical factors included shape, depth number and size of the pond and the effect of light, temperature and wind. Chemical factors take into their gemut the nutritional requirements i.e. organic carbon, nitrogen, phosphorus and dissolved oxygen. Biological factors encompass bacterial and algal activities in such ponds. The significance of oxidation ponds in the recycling of domestic and industrial waste have been emphasised.

Keywords : Oxidation ponds; Environment; Factors; Algal activities.

Introduction

The dawn of this centuary invited the attention of the scientists towards the oxidation ponds, as waste stabilisation ponds have become a part of sewage treatment practice. In the beginning, most of the ponds constructed were designed mainly as holding ponds to conserve water which was later used for irrigation, particularly in water scarce areas. With the introduction of Environment Act 1986, needless to emphasise the significance of oxidation ponds in treatment of sewage, domestic and industrial effluents.

Early in this centuary (Cumming 1916), prior to serious study of waste or sewage ponds, public health officials and limnologists were aware of the fact that oxygen concentration was increased during the day, where there was increased aquatic vegetation including algae. On the other hand, oxygen concentration decreased during night. Cumming (1916) reported that algal masses and submerged plants contributed higher oxygen contents, when compared to those ponds, where fewer algae were present. Thereafter, a number of studies (Ludwig *et al.* 1951, Ludwig and Oswald 1952, Oswald *et al.* 1953) were concerned with algal symbiosis in oxidation ponds and with the growth characteristics of algae growing in these ponds.

Oxidation ponds range in depth between 3–5 feet. The light intensity penetrating to these depths in most of the ponds is insufficient to support the photosynthetic activity. Therefore the lower region of these ponds is usually devoid of oxygen and is anaerobic zone. However, the upper portion, where intencity of light is sufficient to support algal photosynthesis is referred as aerboic zone. Primarily, algae were rendered responsible for acting as primary agents for waste stabilisation in ponds. Further studies suggested that role of algae was basically as a source of oxygen for the aerobic and facultive bacteria, which were considered to be the most important stabilisers of degradable organic matter. Recent studies suggest that the role of algae and aerobic zone is a secondary on which is in polishing the effluent and oxidizing any hydrogen sulphide or odorous gases produced by the anaerobic fermentation of the waste (Khurshed and Chughtai 1986). Still others feel that aerobic conditions should be present throughout the depth of the pond eliminating the anaerobic zone. Although, the role played by each zone is not yet very clear, but it is almost certain that the actual role played by each zone depends upon the specific nature of the treatment. The effectiveness of these ponds much depends upon the interaction, of several factors which may be physical, chemical or even biological. *Physical factors* : This factor takes into its gemut the depth and shape of the oxidation pond, its size and number and the detention time of the waste in the pond. Temperature, light and wind action are other factors of this category.

The depth of the pond is a significant ecological factor as it is directly associated with the light intensity. Oswald *et al*, (1964) have shown that pond depth should be less than one foot, if it is to function aerobically throughout its depth. But such a pond is suitable only if algal production is the main object. Otherwise, most suitable depth range is suggested to be between 5–7 feet. This provides adequate insulation between anaerobic organisms at bottom of the pond and aerobic environ in the upper layers.

The total pond area required to treat the waste of a given community much depends upon the organic contents, usually expressed in terms of BOD (Biological Oxygen Demand) per acre per day. The values recommended so far fall between 20-50 pounds BOD/acre/day. However, reports are on record, (Mars 1957, Svore 1969 and Parker *et al.* 1959) where BOD/acre/day ranges between 263–1230 pounds. Most suitable shape for oxidation pond should be regular in shape without leaving any totally or partially isolated area. This would create hurdles in circulation and invite the undesirable growth of the weeds. Likewise, detention of a given waste in an oxidation pond has many repercursions. Various detention timings have been suggested earlier. Oswald (1964) suggested 40 or more days but Parkar *et al.* (1959) showed five days to be sufficient for highest land use efficiency. The solids detention time greately influences the anaerobic organisms.

Temperature : Temperature is a most important factor in the aerobic environ of the oxidation ponds, as by and far, it determines the succession of predominant species of algae, bacteria and other aquatic organisms. Solar radiation is the main source of heat in oxidation ponds. The temperature range is diiectly proportionate to the depth of the ponds. Stahl and May (1977) have observed a temperature drop to the extent of 20°C in 50 cms of pond depth. The other source of heat is influent in the pond, as temperature of seawage is always lighter than that of the pond contents. High temperature is known to improve the overall performance of the ponds. For optimum activity, temperature should be maintained at the highest range so as to induce the growth of the desirable micro-organisms. Temperature is not only an important factor for aerobic layer, rather it is equally important for anaerobic processes, which convert the waste to the stable products. The efficiency of anaerobic sludge digestion increases with the increase in temperatuie. Howeve', Pipes (1978) feels that the maximum temperature of oxidation pond should be about 30°C. Decrease in temperature range lowered the anaerobic activity of the pond. Oswald et al. (1964) reported the decrease in gas production from 6,700 cu. ft. to 400 cu. ft, when temperature was lowered from 22.5 to 12°C. They further reported that organic solids in an anaerobic pond got partially converted into acids during the periods of low temperature. Gloyna (1978) reported that the heat absorbed by the ground is the most important heat loss from the pond. But Pasveer (1962) found that evaporation and effluent concentration were also important means of heat transfer.

Light : In oxidation ponds, oxygen should be present in reasonably high amounts, in order to support its biological activity. The main source of oxygen is photosynthetic oxygenation. The bulk of the O_2 needad is provided by the algae which they can produce in the presence of adequate light. Intensity of solar radiation varies with the time of the day. It is minimum at night and maximum at noon. Slow and consistant reduction of light results in lowering of photosynthetic activity proportionate to the depth. Stahl and May (1977) reported that dissolved oxygen concentration dropped from 30% at the surface to 3% at a depth of 50 cms.

Wind action : There are three major factors which influence pond operation and performance (Khurshed and Chughtai 1986). Wind action is responsible for surface reaeration, mixing and evaporation. Earl'er workers favoured wind action as it was major source of surface reaeration. But present day workers favour the isolation of Oxidation ponds from wind action as it leads to the evaporation, and cooling of the ponds. Thus the value of mixing is reduced due to evaporation. In addition, deterimental effect of wind action include the erosion of banks by wave action and carrying the undesirable odours.

Chemical factors : These factors mostly incorporate the nutritional requirements of micro-organisms including organic carbon, nitrogen and phosphorus. Of course, dissolved oxygen has a direct relevance with the oxidation ponds.

Organic Carbon : The decomposable organic content is commonly measured in terms of biochemical oxygen demand. The standard practice is to use the five day BOD, as an index of the organic carbon content. The standard BOD estimation is hampered by the presence of large concentrations of algae and effluents from various sources. Since algae in the light normally contribute oxygen to the environment. If the test is performed in the dark, the algae will shift to respiratory metabolism. However it is still believed that the results from the ponds will be higher, even if the algae were to be removed. The large number of bacteria, fungi, protozoa and unstable organic matter will contribute to BOD. Pipes (1978) pointed out that for optimum BOD reduction, it is essential that the organic carbon be in shortest supply, when compared with other organic nutrients.

Nitrogen : In recent years, much attention has been paid to the algae as they form blooms, when nitrogen and phosphorus are available to them. Sawyer (1960) has pointed out that ammonia is obtained chiefly through bacterial decomposition of dead plant and animal protein. An additional method is through the bacterial reduction of nitrates to nitrites to ammonia under anaerobic condition. The available nitrate nitrogen is probably assimilated quickly by the algal cells. In ponds both these activities result in reduction of total nitrogen.

Gates and Borchard (1964) reported that by supplementing inorganic carbon 50% nitrogen removal was achieved in one day, 95% removal in 4 days by algal cultures but under controlled condition.

Phosphorus : It is the well known fact that phosphorus is an important nutrient involved in algal metabolism. It is the growth limiting factor in aquatic environ. Sewage ponds, receiving domestic seawage are generally rich in phosphorus contents, as it is the basic constitutents of detergents. Major portion of the phosphate enters the pond system via media of the sludge. However, oxidation ponds are known to have reduced concentration of phosphates. Bogan *et al.* (1960) reported 80% phosphate removal in four hours by algal cultures under laboratory condition (Khurshed and Chughtai 1986). The mechanism of phosphate removal is said to be the absorption, coagulation and p ecipitation, accompanied by high pH. due to algal activities.

Dissolved Oxygen : The solubility of oxygen mostly depends upon the temperature and atmospheric pressure. As the temperature rises the solubility of oxygen in water decreases (Sawyer 1960). Another important factor may be the presence of protozoa, bacteria and fungi in great numbers, sinne they all use oxygen in respiration. Wind direction also sometimes has an effect on dissolved oxygen.

There are two sources of dissolved oxygen in the ponds, surface reaeration and photosynthetic oxygenation. According to Raynold (1975) reaeration is relatively insignificant factor for disolved oxygen concentration. With this, the dissolved oxygen quantity much depends upon the photosynthetic activity, which becomes low at night and high at noon.

Biological factors : These factors mostly encompass bacterial and algal activities in any oxidation pond. The contributions of bacteria are in decomposition of organic matter into oxidised endproducts (Khurshed and Chughtai 1986). There is a broad spectrum of variation of bacteria in the ponds i.e. aerobic, acid forming, methane producing, purple-sulphur and pathogenic bacteria. Aerobic bacteria are concerned with the decomposition of organic matter in the presence of oxygen, while acid forming bacteria are facultative heterotrophs. They convert complex organic material into volatile acids (Khurshed and Chughtai 1986). The methane forming bacteria, are, however, obligate anaerobes. These bacteria convert volatile acids to methane and carban dioxide. Their pH requirements range from 7 to 8. The inhibition of methane bacteria leads to the enhanced activity of acid forming bacteria, which shift the pH to acidic side. Loehr (1972) observed the minimum temperature requirement for activity of methane bacteria to be 18°C. Undesirable odour problems develop around the ponds, if methane forming bacteria are not active. The pH, temperature and anaerobic conditions are primary requirements of methane producing bacterial population.

The purple sulphur bacteria are photosynthetic and microaerophilous. The convert sulphids into sulphur or sulphates. The activity of these bacteria is significant in controlling the odour of sulphides. These bacteria mostly form blooms during warm periods and impart pink or red colour to the pond water (Khurshed and Chughtai 1986). In addition to pathogenic bacteria, viruses and protozoa also inhabitate oxidation ponds. The most probable number of coliform organism in a given volume of water is regarded as index of pathogenic quality of an effluent.

In contrast to bacteria, algae constitute a group of aquatic organisms, possessing photosynthetic pigments. They are autotrophic organism and photosynthetically transform inorganic nutrients into cellular organic material releasing oxygen as a by-product. Many species of algae have been observed in ponds including green, blue greens, euglenoids and diatoms. Their dominance depends upon temperature, nutrient availability and presence of toxic substances. Algae and bacteria are supplementary to each other in the ponds. Bacteria break down the organic matter aerobically and also unaerobically into simpler products, which are in turn utilized by algae for their growth, with the release of oxygen. This oxygen is essential in maintaining the aerobic enxironment.

It may be concluded that optimum conditions for the operation of an oxidatian pond are associated with the microbial population. This population in turn is effected by physical and chemical factors operating on the pond water. The most of the interactions between physical, chemical and biological factors should be so, that the oxidation ponds can be operated to produce products of value and an effluent with a low nutrient content and few pathogenic bacteria.

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