C H A P T E R

VII

STUDIES ON SLIMY GROWTHS COLLECTED FROM DIFFERENT SITUATIONS IN THE TWO SEWAGE DISPOSAL WORKS AT BARODA AND THE ONE AT NEW DELHI

In the preceeding chapter, results of the studies made on viscous scum which develop at the surface of stored samples drawn from different situations of a few sewage disposal works in India are given. In this chapter an account of the results of mieroscopic examination of "slimy growths" collected from different places of three important sewage disposal works in India is furnished.

"The phenomenon of flocculation and bio-flocculation is one of common occurrences in nature. Slimy growths developing on submerged surfaces such as stones and sticks in a stream are manifestations of this phenomenon. Similarly, some of the growths produced on sewer walls, conduits, tank walls, etc. are excellent sources of organisms which under favourable conditions can bring about clarification of sewage." (Heukelekian 1941).

"Slimy growth" differ morphologically from the viscous scums formed at the surface of stored sewage in forming thin or thick encrustations or long, trailing filaments while the latter do not. They are, also, often seen in different situations of a sewage disposal works.So, an attempt is made in this chapter to review the literature relating to the role of "slimy growth" in the purification of sewage and to describe the results of microscopic examination of "slimy growths" collected from several places in three Sewage Disposal Works in India for comparison with the viscous scums formed at the surface of stored sewage.

Heukelekian and Crosby (1953) have also described the formation of slimy growths seen on submerged surfaces in contact with waters polluted with sewage and industrial wastes as a common phenomenon. Such growths are also reported by them to occur in sewers, attached to the side walls below the liquid level in sedimentation tanks holding sewage or industrial wastes, in cooling water circuits, in plant processing units, in paper making machine, in water lines and in waters containing various types of organic materials. They add that the types of organisms producing slime vary with the nature and concentration of food materials and include zoogloeal and filamentous bacteria, fungi, algae, protozoa, insect larve and worms; and that the role played by these growths in sewers is not clearly understood. Harrison and Heukelekian (1958) have made a literature review of " slime infestation " and have quoted Tieg's (1938) early description of "abwasser pilz community as consisting of Sphaerotilus natans, Zoogloea ramigera, Beggiatoa alba, Thiothrix nivea, Fusarium aquaeductase, Leptomitus lactens and Mucor sp." Taylor (1963-64) has found " Cooling waters and ponds in the vicinity of trees and other vegetation often suffer most from slime due to the presence of increased oxygen and carbon dioxide from respiration and photosynthesis." Poynter and Mead (1964) attempted to elucidate the cause of the formation of slime on London water taps exposed to atmospheres contaminated with vapours of volatile organic liquids. They have adduced evidences to show that slime formation depends for its start on the presence in the water supply of certain species of bacteria and fungi both of which utilize ethanol. They have found that the organisms responsible for slime formation are mostly derived from the water although aerial strains may also contribute to slime production under certain conditions; that certain compounds such as ethanol, are found to be a most prolific slime inducers, while methanol, isoproponal, n-butanol and acetone induce visible but markedly restricted growth on the taps after 6-8 weeks of continuous dripping. The bacteria responsible in all these cases belonged to the genus Pseudomonas and the fungus was identified as Monilia humicolor. All the bacterial strains were " motile, Gram-negative rods of variable morphology ranging from cocco-bacillary forms through short, slender sometimes curved rods to filaments. All were aerobic, oxidase positive, methyl red negative, Voges - Praskuer negative, and none was able to oxidise dulcitol. Glucose, maltose, arabinose, galactose, and cellobiose were oxidised by all strains. "

They examined a slime taken from a tap chemically and found it to resemble a mixture of polysaccharide and simple peptides.

Mackenzie (1938), in one of his annual reports, has described the occurrence of slime in some consumers' house taps as "fungal slime" or "alcoholic fungus" and that the mass consists of interwoven fungal hypae, numerous bacteria and protozoa. Greathouse, Wessel and Shirk (1951), in their survey of the microbial deterioration of various manufactured goods, ascribed the spoilage as being due to several groups of microorganisms, chief of them being Escherichia and Aerobacter, the non-spore bearing genera Micrococcus and Pseudomonas along with the genera Achromobacter, Flavobacterium, Alcaligenes and Cellulomonas playing a secondary role.

But Varma and Reid (1964) have stated that slime growths are responsible for the biological reduction of organic wastes; that "most of the slimes consist of aerobic bacteria and their waste products (sugars and gums)"; that the major bacterium of interest in biological treatment is Zoogloea ramigera; and that this "bacterial slime" has been shown to be the major factor in bio-oxidation of organic wastes by many investigators such as Flugge (1886); Buswell and Long(1923); Butterfield (1935); Heukelekian and Schulhoff (1938); Falk and Rudolfs (1947); Beardsley (1949); Helmers, Frame, Greenberg and Sawyer (1951); Heukelekian, Orford, and Manganelli(1951); McKinney and Horwood (1952); McKinney and Weichlein (1953); Eckenfelder (jr) (1956); Elsden and Peel (1958); Dugan and Lundgren (1960); and McKinney (1960).

Gainey and Lord (1961), on the other hand, state that sewage contains ordinarily 25 to 50 ppm of fat and since fats are lighter than water, they tend to accumulate on the surface, and so in some sewage treatment plants, provision is made for bringing fats to the surface and trapping them. The accumulation of fat on the surface of stored sewage seems to be different from the long trailing filaments or incrustations of slimy matter.

From the foregoing it will be seen that the formation of slimy growths is a common phenomenon taking place under various ecological conditions; that slimes developing from water supplies are due to Pseudomonas spp and probably resemble the extra-cellular slime of Pseudomonas solanacearum comprising a mixture of polysaccharides and simple peptides (Dudman, 1959); while the slimes formed in sewage or other organic wastes are due to Zoogloea ramigera, which is the chief bacterium of interest in aerobic biological waste treatments. In all the cases mentioned above, slimy growths have been reported to occur either under water or on aerially exposed objects.

During the course of our laboratory studies on the conventional oxidation pond method of sewage treatment, viscous scums were invariably found to develop at the surface (and not below the liquid surface as Heukelekian and Crosby (1953) have found) during the bacterial phase I of the first stage of operation as already reported; however, the scum thus formed was found to contain hundreds of Zoogloeas and protozoans just as in the case of well conditioned activated sludge flocs (Butterfield 1935). Therefore a proper understanding of the characteristics of the biological slimy growths and viscous scums may be useful in evaluating biological wastes treatment systems and for developing new methods of treatment. An attempt is therefore made in this chapter to make detailed studies of the biological slimy growths formed in different situations of the two Baroda Sewage Disposal Works and of the Delhi Sewage Disposal Works at Okhla for comparison with the organisms found in the viscous scums formed with organic liquid wastes.

Slimy growths collected from the Two Sewage Disposal Works at Baroda

There are two Sewage Disposal Works at Baroda: the oldest and the largest is at Wadi, where a part of the 8 mgd of sewage (mostly domestic) is given primary treatment only; and the latest and the smaller one is at Atladra where about 3 mgd of a mixture of industrial wastes mostly from two large pharmaceutical and chemical manufacturing concerns and sanitary wastes from people residing in areas west of the railway line are receiving primary and secondary treatments. The slimy growths or incrustations formed on the walls of the treatment units in different situations were examined fortnightly from January 1968 and the results of their microscopic examinations are reported below.

Wadi Sewage Disposal Works

Raw sewage channel. The incrustations formed below the water level in several places in the channel were collected and examined once a fortnight. Only on one occasion in the first fortnight of April 1968, the incrustations showed the presence of a single, small, finger-like colony of Zoogloea. On other occasions a few threads of Oscillatoria spp were seen.

Launder walls of the continuous flow preliminary settling basin. Here reddish and greenish growths were seen. The reddish growths could not be correctly identified but the green growths were found to consist of threads of Oscillatoria chalybea. No other organisms were seen.

Atladra Sewage Disposal Works

From the flowing grit channel. The slimy growths found adhering to the wall below the water level on June 30, 1968 were found to consist of a few Zoogloea colonies, small sized Vorticella sp with long stalks, teletroch forms and minute protozoans. It was surprising to note the above organisms in that worst situation- putrid, H_2S- producing, black raw sewage. On other occasions such forms were not seen.

From the launder wall of the continuous flow settling basin. The slimy growths collected from this situation also showed the presence of a few forms of Vorticella microstoma, minute protozoans and diatoms. Zoogloea colonies were not seen.

From the stones of the trickling filter No.2. Three kinds of slimy growths were collected: greenish, whitish and brownish. The greenish growths formed on the stones were found to consist of Chlorella vulgaris and small sized Vorticella sp. but no zoogloea. The whitish growths were found to consist of Beggiatoa alba, Chlorella vulgaris, Paramecium caudatum, and Notholca sp (a rotifer). The brownish growths were found to consist of Vorticella microstoma; minute protozoans; and a few Zoogloea colonies. The latter were single and short colonies, finger-like as in activated sludge flocs and not as in the viscous scums formed at the surface of stored sewage.

From the launder wall of the final settling tank. The slimy growths collected from this place were found to consist of two species of Vorticella: Vorticella microstoma and Vorticella sp. and Spirilla.

Slimy Growths Collected from the Delhi Sewage Disposal Works at Okhla

On January 14, 1968, the author had the opportunity to visit the Delhi Sewage Disposal Works at Okhla and the occasion was availed to collect " slimy growths " from different situations in the sewage Disposal Works at Okhla. The results of microscopic examination of the six samples collected from the works are shown in table 7-1 from which the following observations are made.

Zoogloea colonies along with Opercularia sp and Vorticella sp. were seen in the slimy growths collected from the filter stones in the Dorr-Oliver trickling filter.

Table :7-1: Results of Microscopic Examination of Slimy Growths collected from Different Situations in the New Delhi Sewage Disposal Works at Okhla on January 14,1968 between 12 noon and 1.00 p.m.

Slimy Growths	Zoogloea colonies	Naias worms	Rotifers	Oscillatoria			Diatoms		:Vorticellidae	
				Short Sp_1	Thick Sp_2	Thin Sp_3	Nitz Schea palea	Another bigger one	Oper-cula-ria sp	Vorti-cella sp
1. From the wall beneath the liquid in the primary settling tank effluent	--	c	-	ccc	-	-	-	-	-	-
2. From the Stones in the Dorr-Oliver Trickling Filter	r	r	-	ccc	-	-	-	-	-	-
3. From the Launder in the sedimentation basin of Dorr-Oliver Trickling Filter	Nil	-	-	-	rr	rr	ccc	r	r	-
4. Attached to the surface of Simplex aerating cones in action	r	-	rrr	-	-	-	-	-	ccc	-
5. Trailing filaments under water from iron bars in the sedimentation basin of the mixed liquor from Simplex aerators	rr	-	-	cc	ccc	cc	r	rr	c	-
6. Gelatinous trailing filaments from grass attaching to the bank of the channel carrying the final mixed effluents to the river.	-	-	-	-	-	-	-	-	cc	-

Slimy growths attached to the surface of Simplex Aerating cones (activated sludge process of mechanical type) in action showed the presence of zoogloea colonies, a rotifer Brachionus sp and many Opercularia sp. colonies.

The long trailing filaments seen under water in the final sedimentation basin of the mixed liquor from the activated sludge process of mechanical type Simplex aerators cones were found to contain Zoogloea colonies, Opercularia sp, diatoms and blue-green algae (Oscillatoria spp).

The slimy growths collected from the wall beneath the liquid in the primary settling tank effluent, from the launder in the sedimentation basin, of the Dorr-Oliver trickling filter; and from the grass attached to the bank of the channel carrying the final mixed effluents to the river did not show the presence of Zoogloea colonies, but showed the presence of Opercularia spp.

DISCUSSION

Various theories have been advanced regarding the role of slimy growths in sewage purification and they may be broadly grouped under two heads:(i) physical and (ii) biological. Two of the important ones are discussed below :

The physical theory as expounded by Biltz and Krohnko(1904) is that the slimy growths consisting essentially of plant and animal organisms are able to adsorb colloidal matter present in sewage with the formation of an adsorption compound of the colloidal matter and the gelatinous coating. Then the adsorbed matter is directly oxidised by chemical means with the help of the oxygen present in air. In this way, the slimy growths are helpful in providing adsorptive surfaces for sewage purification.

Whitehead and O'shaughnessay (1936) on the other hand have proposed a biological theory about the role played by slimy growths in sewage purification. They stated that in sewage containing soluble nutrient substances, bacteria, in the presence of oxygen, produce a gelatinous matrix (viscous scum, or activated sludge or biological slimy growth) which furnishes the basis for sewage purification. According to them, there is practically no difference microscopically between the gelatinous material(viscous scum) formed when sewage is allowed to stand undisturbed, the slimy growth collected from a mildly polluted stream and activated sludge flocs. The three biological growths represent a manifestation of the same process varying naturally as to degree. It is,therefore, to be expected naturally that the organisms involved though may be closely allied, "belonged to different species not only in the stream, sewage and activated sludge but within the same process at different times. "

Reid (1958) considered 'sewage slime' as a gelatinous matrix of bacteria and their gum products on which various higher forms such as protozoa are feeding. He thought that the slime would grow on any surface, smooth or rough, provided there is nutrition and a water - air interface. It might also grow as a free-floating mass. The activated sludge flocs and the trickling filter slimes are examples of both.

The slimy growth, according to him, was a sort of "fundamental society where the bacteria consumed the soluble food material and the animal forms in turn, consumed the bacteria with a whole chain of inter-related events. Zoogloea ramigera was generally considered to be the basic bacterial group in it. So, it was responsible for most secondary sewage treatment processes, recovery of polluted streams. "

We have shown in the preceeding chapters the general composition of the viscous scums formed at the surface of stored raw sewage, of the slimy growths formed in different situations of three sewage disposal works and activated sludge flocs to consist of zoogloea colonies, stalked and free swimming ciliated protozoa and blue-green algae. There is no doubt that the presence of preformed slimy growth accelerates the rate of flocculation and clarification as shown by Clark (1930)." But what is the cause of this acceleration ? Is it mass inoculation with specific organisms or the presence of the organisms creating an adsorptive surface wherein the process of hydrolysis and oxidation may be carried out at a more accelerated rate ?" (Heukelekian 1941).

All the three types of biological growths - viscous scum, slimy growth or activated sludge floc - have common characteristics as stated already. They generally consist of zoogloeal colonies ofbacteria and certain protozoans. The number of individual rods in a given colonial growth of zoogloea, according to Butterfield

(1935), may run into tens of thousands and thus constitute the major portion of solid matter. Such zoogloeal colonies are found in far greater numbers and in bigger sizes in the viscous scums formed at the surface of stored raw sewage (especially during bacterial phase I of an oxidation pond) than in the other two types of biological slimy growths.

How do these zoogloeal colonies act then, in the process of sewage purification ? They may act directly as such, as they may well do with the soluble organic constituents in sewage or they may be active through their enzymes secreted in the liquid phase or the insoluble materials are first adsorbed on the capsular material envoloping such zoogloeal colony, before further action is taken by the hundreds of individual cells comprising each colony (Heukelekian 1941).

SUMMARY

1. "Slimy growths" formed on submerged surfaces and the viscous scum formed at surface of stored sewage are compared and contrasted.
2. "Slimy growths" collected from the Sewage Disposal Works situated at Baroda and Delhi are described.
3. The role of "slimy growths" in sewage purification and their similarity to the viscous scum are discussed.