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Effluent Treatment Plant on dyeing of Textile

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This process is similar, under a certain point of view, to what normally happens in a water course, but quicker and in less space.

It is easy to understand that all contributing to environment forming in which bacteria develop their action, must be rigorously balanced and related, to offer a greater opportunity of development, in no way inhibiting any of the treatment phases.

So we understand that a biological activated sludge plant is to be compared to a micro ambient with proper chemical physical factors (temperature, pH, dissolved oxygen etc.) in which the microbial biomass develop its proper vital cycle (reproduction included) and tends to establish its own regime; by means of this equilibrium the best efficiency conditions of the plant will be achieved.

Keyword: Neutralization, Biological Oxidation, Sludge recycling, Micro Organism, pH, DO, BOD, COD, TDS.

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"Study on Effluent Treatment Plant on Textile dyeing"

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1) RULES FOR THE MANAGEMENT OF BIOLOGICAL ACTIVATED SLUDGE PLANTS FOR INDUSTRIAL WASTE WATER TREATMENT

Abstract

The biological activated sludge treatment, is based on the use of bacteria and micro organism, which, if kept in determinate environmental circumstances, are able to destroy polluting organic matter. From metabolism of organic matter, growth and developing of an activated bio mass, CO_2 production, water, mineral salts and inorganic products of biological waste, are determined.

This process is similar, under a certain point of view, to what normally happens in a water course, but quicker and in less space.
It is easy to understand that all contributing to environment forming in which bacteria develop their action, must be rigorously balanced and related, to offer a greater opportunity of development, in no way inhibiting any of the treatment phases.

So we understand that a biological activated sludge plant is to be compared to a micro ambient with proper chemical physical factors (temperature, pH, dissolved oxygen etc.) in which the microbial biomass develop its proper vital cycle (reproduction included) and tends to establish its own regime; by means of this equilibrium the best efficiency conditions of the plant will be achieved.

Keywords: Neutralization, Biological Oxidation, Sludge recycling, Micro Organism, pH, DO, BOD, COD, TDS etc.

PLANT COMPOUNDS

The parts which constitute a waste water treatment plant are the following:
<u>SCREENING, STORAGE, NEUTRALIZATION, BIOLOGICAL OXIDATION, SEDIMENTATION, SLUDGE RECYCLING, EXCESS SLUDGE THICKENING.</u>
We herewith touch upon each of them.

SCREENING:
Has the goal to separate coarse and fine matter at the inlet of the plant, avoiding sedimentation and clogging in the successive stages.

STORAGE AND HOMOGENIZATION:

These operations are carried out to render the feeding in the oxidation stage as constant as possible, either under quantity's point of view or in polluting load.

The mass is kept in continuous movement by forced mixing, which is obtained mechanically, and by micro-bubble oxygen injection; in this phase also a pre-oxidation stage of the waste water is achieved.

Feeding to the following biological phase is assured by a pump which decants the water, stored within 24 hours, ensuring a constant and balanced flow to the oxidation tank.

NEUTRALIZATION:

The water at the inlet is exposed, to even remarkably pH value differences; for this reason we have a neutralization stage. In fact, the biological plant, to be exploit and managed in the best of ways, needs at the inlet waste water at a neutral or slightly alkaline pH value and the most constant possible.

Neutralization occurs automatically, pH meter controlled and carried out with acid or soda by volumetric dosing pumps. Their enter upon working is automatic and such to stabilize the pH between 7 e 8.

The reading of the pH value is done by a glass probe (electrode) which is easy to be substituted in case of damage or wear. If necessary, in the tank it is even possible to provide for reduction of eventual free chlorine, through automatic adding of sodium disulphite, pre-set by an instrument for redox control.(OPTIONAL)

BIOLOGICAL OXIDATION:

It is carried out in a generally rectangular tank (it may also be square or elliptical shaped) in which, through the action effected by bacteria and aerobic micro-organism on the polluting load, occurs the real and proper waste water treatment. The necessary oxygen supply in this phase occurs by blower groups.

The high efficiency in the oxygen transfer achieved in the oxidation tank, is due to injection of oxygen under form of micro-bubbles, achieved through employ of oxygenizers of various type, such as elastic membrane diffusers with membranes in special EPDM mixtures, or those with high density polyurethane diffusers.

The injected oxygen, rising towards the top, creates whirlpools which ensure movement and mixing of the bacteria to the waste water to be treated, simultaneously avoiding dangerous sedimentation or sludge clogging on the bottom of the tank.

NUTRIENT SALTS FEEDING.

With the goal to maintain a correct and well balanced feeding of the micro-organism in the oxidation tank, a dosing system of phosphor and nitrogen based nutrient salts, indispensable to life and development of micro-organism responsible for the treatment, has been provided.

The supply of nutrient salts is particularly important during the start up phase of the plant or during production breaks; in the latter the supply of salts must also provide for a sufficient quantitative of organic matter, to keep the bacteria alive for the total break period.

Feeding is carried out by a pre-set automatic dosing pump, so the supply of the salts must be regulated by the operator, in function of the effective need of the plant.

The quantitative of salts to be dosed into the oxidation tank shall guarantee, a minimum ratio of 100:5:1, between BOD-Nitrogen and Phosphorus.

SEDIMENTATION.

It has the goal to clarify the water at the outlet of the oxidation tank, allowing the sedimentation of the activated sludge on the bottom of the tank and its successive recycling.

The mixture of water and sludge coming from the oxidation tank, is put into the middle of the sedimentation tank by a special pipe. In the sedimentation tank, due to the low ascensional speed, the biological sludge flocs separate from the water and settle on the bottom, while the clarified water, free of substances in suspension, goes out from the top of the sedimentation tank by overflow.

The clarified effluent, can now be discharged freely into the receiving hydro body.

SLUDGE RECYCLING STATION

The sludge which is separated from the water in the sedimentation phase, are forwarded to the central sump by action of a bottom blade, with which the scraping bridge is equipped. Through a pipeline, the sludge is put into a collecting sump and then, by means of electro-pumps collected to pipes and valves, recycled to the head of the oxidation tank.

Sludge recycling is an essential phase of the entire waste water treatment cycle, as it avoids an impoverishment of the content of activated bio mass in the oxidation tank, and anoxaemia or anaerobioxic phenomena of the activated sludge in the sedimentation tank.

In this way we will have the possibility to regulate the quantity of the biological sludge, necessary to the efficiency of waste water treatment.

The sludge recycling must be regulated in such a way, to achieve a sludge quantity in the recycling stream, more or less twice compared to that in the oxidation tank.

Estimation of the present sludge quantity must be carried out in an Imhoff cone, after 30 minutes of sedimentation.

Simultaneously, with the very same pumps, the by the biological plant produced excess sludge can be discharged.

EXCESS SLUDGE STORAGE AND THICKENING:

During the sedimentation phase also a consistent thickening of the sludge occurs.

But this action does not reach remarkable values, so if we want to achieve thicker sludge, we need to dose, after storage in a special tank, a suitable flocculating agent such as cationic organic polyelectrolyte, at high molecular weight.

Successively, mechanical dehydrating systems such as drying beds, blade-, belt or filter presses as well as decanters, can be used.

FUNDAMENTAL CHECK POINTS AND FACTORS WHICH INFLUENCE THE EFFICIENCY OF PLANT OPERATION

The operation of the activated sludge plant requires control of the index parameters of functioning of the process hereafter described, and the la regular maintenance of the equipment.

Control is carried out by means of simple tests (pH, OD, VF) effected directly on the plant as frequent as above indicated or with a frequency that may establish the operator himself based on his experience and the plant's need.

Periodically, more complete analysis in specialized laboratories must be performed.

Even very important are the observations of the operator, who will be able to estimate the plant's running also based either on the aspect, the smell and the colour of the sludge or on other phenomena which may be noticed by managing the plant.

PARAMETERS:

1) pH - It is the indication of acidity or basic (alkalinity) of waste water. The effect of pH on the biological oxidation process is important for the influence that it has on the enzymatic reactions; in fact, each enzyme has its optimum pH of activity, which when changed, diminishes its reaction speed.

   Besides influence on the biochemical reaction, the pH has a selecting effect compared to the micro-organism: as in slightly acid surroundings moulds compete with bacteria and prevail over them at values of 5.5-6. This phenomenon creates remarkable inconvenience to the management, as it worsens the sludge sedimentation strongly and as a consequence it reduces the purifying efficiency.

   Considering then, that bacterial cells have a prevalently protein composition, and that by pH less than 5 and more than 9,5 occurs protein denaturation, it is easy to intuit that in the aforesaid pH condition they will be done to death in a short time.

Moreover, a quick pH exchange might remarkably diminish the breathing activity of the bio mass; therefore it is important to have recourse to neutralization and homogenizing of the effluent before recycling into the oxidation tank.

As a rule, at the inlet of the plant there is a pH value oscillating between 6.5 and 8.5, provided that the pH of the aerated mixture is maintained as constant as possible with a value between 7 and 8.

2) TEMPERATURE - The reproduction speed of micro-organism is strictly related to the condition of temperature, as this factor influences all reactions, either chemical or biological.

In fact, we must bear in mind that the temperature is important either for protoplasmic synthesis, or for metabolism, but intervenes even in the efficiency of either bioflocculation or O_2 transport from air to water and from water into the activated sludge floc. Indicatively, 25°C represents the ideal temperature for the management of an activated sludge plant, even if the biological activity persists between 4 and 40° C, with different results.

It is very important to remind, that more than its value, it is most import not to have sharp temperature variations in the oxidation tank.

3) DISSOLVED OXYGEN - Indicates the dissolved oxygen concentration in the aerated water-sludge mixture. It is measured in mg/l or ppm. Presence of dissolved oxygen is a fundamental condition to realize an aerobic biological process.

When the dissolved O_2 concentration in the activated water-sludge mixture is higher than 1,5-2 ppm, the bacterial respiration speed proceeds regularly; only for the nitrification reaction it is fundamental to assure dissolved oxygen levels higher than 2 ppm.

High O_2 levels(over 4 ppm) indicate only a waste and thus affect negatively on the running costs.

If on the contrary we operate at an O_2 concentration less than 1 ppm, the sludge might undergo a morphological modification, in fact, the microbial cells tend to amass in big sludge flocs, diminishing so the transfer speed of O_2 towards the interior of the floc, which leads to have to reduce the specific organic load, to achieve the same purifying level. Therefore, in the aeration tank, we try to maintain values of dissolved O_2 between 1,5 and 2,5 ppm.

4) CONCENTRATION OF THE BIOMASS (SST) - The concentration of the biomass must be proportional to the concentration of BOD (COD) to be degraded and to the retention time in the oxidation tank; usually the recommended value in the tank varies from 3,5 to 5 gr/l even if for strongly polluting effluents we could use concentrations higher than 6-7 gr/l. On the contrary, a sludge which is poor of suspended solids is not very efficient to purifying, because either the degradation capacity or the bio-flocculation capacity and absorption, reduce to very low or negligible levels.

The percentage of organic compounds of the biomass, the so called volatile fraction (SSV) must be maintained on a value between 70-80% of the total suspended solids.

A higher value is a consequence of excessive organic load, while a lower value indicates mineralization phenomena of sludge as a consequence of a strongly forced oxidation, very low organic load of the sludge, very old aged sludge, or presence of notable precipitation of inorganic matter.

5) SLUDGE SETTLEMENT AND SLUDGE INDEX (SVI) - Sludge able to carry out an efficient purifying action settles quickly; it is considered that sedimentation is efficient when we have a sludge index (SVI) between 100 and 150. The sludge index or SVI, represents the volume which occupies one gram of biomass, after 30 primes of sedimentation in an Imhoff cone.

The formula for the calculation of SVI is the following:

$$\frac{\text{Dry sludge value at } 105°\text{c expressed in gr/lt}}{\text{Decanted sludge volume expressed in cc}}$$

NB: for valuation of the decanted sludge volume we must put into the Imhoff cone 1 lt aerated mixture, drawn from the oxidation tank, the value of the sludge quantitative should be read after 30 minutes of sedimentation.

Increase of SVI could be due to numerous causes, of which we remind:

Insufficient tenor of O_2, pH- or organic load shock, absence or insufficiency of N and P nutrients, presence of toxic discharges, start of a putrefactive process, sugar excess, initial of predominance of filamentous bacteria, etc.

A too low SVI value, is generally due to excessive sludge mineralization; in this case it may be useful to reduce the SST value in the oxidation tank, in order to increase the charge of the sludge (In some case it will be useful to effect the sedimentation curve of the sludge in function of time).

NUTRITIVE SUBSTANCES

To favour increase and development of micro-organism it is necessary that the to be treated effluent contents a suitable quantity of nutritive elements and particularly N and P; generally we need to maintain the ratio in weight BOD:N:P as 100:5:1.

Deficiency of such nutritive elements, frequent in industrial effluents, in concomitance with other factors (incorrect pH, low O_2 tenor, etc.) may favour multiplication of filamentous micro-organism and cause the phenomenon of sludge bulking (bulking), which slows down and some time impedes sedimentation.

TOXIC SUBSTANCES

The activity of the biomass may be inhibited by presence of some organic and inorganic substances content in industrial effluents.

Particularly noxious result heavy metal salts; generally it is considered that cadmium, mercury, lead, copper, nickel, zinc e chrome initiate influencing negatively the process when the concentrations are some fraction of mg/l.

Among the other inorganic substances that could be found in industrial effluents which inhibit the activated sludge process, there is chlorine which influences negatively at concentrations of more than 0,3 mg/l.

A toxic action on the bacterial flora could even be due to numerous organic substances such as: phenol, cationic surfactants, etc. As regards the anionic and non ionic surfactants we should observe that, even if they are scarcely bactericide, they influence negatively on floc forming due to their dispersing action.

We need to bear in mind that in some cases the micro-organism are able to get used to sensible doses of toxic products, after a certain time of adaptation.

SLUDGE RECYCLING

A correct recycling sludge flow is basically for the efficiency of an activated sludge plant, which must avail constantly of an adequate biomass in phase of oxygenation, able to assure metabolization of the polluting organic load.

As said before, to maintain a sufficient concentration of activated bio mass in the oxidation tank, it is necessary to apply to recycling of the sludge coming from the decanter.

Usually the recycling flow of an activated sludge plant is between 50 and 150 % of the feed flow.

A recycling flow, which is able to assure a recycling sludge concentration double compared to the sludge in the oxidation tank, can be considered optimum.

The valuation of the concentration of the sludge must be carried out in an Imhoff cone after 30' of sedimentation.

TOTAL ORGANIC LOAD

It is the ratio obtained, referring the quantity of organic substance to be degraded with the total sludge amount i.e. Kg. BOD day/Kg. SST.

Based on this ratio we can subdivide the plants in four classes:

A) HIGH LOAD: higher than 0.5 Kg. BOD/Kg. SST/day. In this kind of plant it is possible to degrade about 70-80% of soluble BOD.

The volume of the oxidation tank allows a retention of three hours and the SST quantity is between 1 and 2 gr/l. These kind of plants produce a remarkable sludge quantity to dispose off (more than 0,8 Kg/Kg BOD removed) with very short retention times, but also with a final opalescent effluent and with a rather high BOD residual.

B) MEDIUM LOAD: between 0.1 and 0.5 Kg. BOD/Kg. SST/day. The purifying efficiency of these plants may achieve 90%.

The retention time in the oxidation tank various between 3 and 16 hours, while the SST content is kept between 1,5 and 4 gr/l.

The medium load plant gives a much cleaner effluent than the aforesaid, with a sludge production around 0,6 Kg/Kg abated BOD.

C) LOW LOAD: between 0.05 and 0.1 Kg. BOD/Kg. SST/day. In this case purification levels higher than 95% are achieved, producing a limited sludge quantity (less than 0.2 Kg/Kg. removed BOD) while the retention time in oxidation various between 16 and 40 hours.

D) TOTAL OXIDATION: less then 0.05 Kg. BOD/Kg. SST/day.

Plants subjected to a similar load have a purifying efficiency oscillating between 85 and 95% and a practically inexistent sludge production, while the retention time is over 40 hours.

The two “low load” and “total oxidation” systems produce an effluent with very little BOD, but with a fairly good suspended solids content, due to the dragging of the abundantly mineralised sludge.

But in return, the excess sludge to be disposed off is very little.

ACTIVATED SLUDGE PROCESS REGIME CONTROL

The activated sludge plant's running requires control of some parameters which indicate the functioning of the process and the regular maintenance of the equipment.

The control occurs by simple tests, carried out directly on the plant with the indicated frequency, or with a frequency due to the plant's need.

Periodically, more complete analysis in specialised laboratories must be carried out. Even the operator's observations are very important, who could estimate the plant's running also based on the aspect, smell and colour of the sludge or through other phenomena which could occur.

SLUDGE VOLUME OR IMHOFF CONE PROOF

Gives expression to the decanted sludge volume in a cylinder (or cone) of 1 lt. within 30 minutes. This test, even if not sufficient to give a complete description of the de situation all by itself, will be however able to signalise in advance eventual functioning anomalies. Such tests must be carried out every day.

The formalities are the following:

- to pour into the Imhoff cone (or into a 1.000 cc. cylinder) one litre aerated mixture which has been taken from the oxidation tank and observe the sedimentation of the sludge.

When the plant runs correctly we should see an immediate and net separation between sludge and water, which must remain limpid.

Particularly, after 10’ about 50% of the in 30’ settled sludge, must be settled down.

One time each 15 days it might be useful to notice the decanted sludge, every 5 minutes and put the registered values in a graph.

Every now and then it will be just as well to carry out an Imhoff proof on the recycling sludge as well, with the goal to value the appropriated regulation of the sludge recycling. In fact we should remember, that the recycling must be regulated to maintain the ratio between recycling sludge volume and oxidizing sludge volume between 1,5 and 2.

If the decanted sludge volume is higher than 700 cc it would be just as well to take a proof, diluting the sample at 50% with water taken at the outlet of the plant.

pH

The test must be carried out every week, with the goal to check the correct functioning of the controlling equipment. It must be carried out on the water at the inlet, on the aerated mixture and on the water at the outlet. For this proof indicator paper could be used and, with much more precision, a portable pH meter. The pH in the oxidation tank must be kept between 7 and 8.

INCONVENIENCE

The plant has been designed as to run at a minimum of attention and without difficulties. When it runs normally, the final discharge should result clean, without any smell and limpid. If such should not occur, it should mean that some inconvenience have turned up which, generally, are easy to solve. The principal inconveniences regarding the activated sludge process are the following:

a) Altered aspect of the sludge.
b) Foam forming in the oxidation tank and in the final decanter.
c) Poor sedimentation of sludge and poor concentration of suspended solids in the sludge, the phenomenon presents two aspects;
    1) poor sedimentation and a turbid effluent

2) sludge swelling

d) Sludge rising.

SLUDGE APPEARANCE

By experience the operator will be able to understand precise signs from the running of the plant as well as from the observation of the appearance and smell of the sludge. Good sludge has a dark colour and is has almost no smell, or has a slightly sweet smell.

If the smell becomes strong or nasty and the colour greyy, it means that the fermentation is going to become anaerobic and such might mean that more air in the oxidation or less retention time on the bottom of the decanter are needed, in the second case increasing of the recycling sludge flow is required.

Oxygen: to check daily the dissolved oxygen value and to transcribe in the apposite table; verify and calibrate monthly the oxygen meter as advised by the manufacturer.

Temperature: to check desultorily, especially in cold periods, the water temperature in the oxidation tank and transcribe the data in the table.

Suspended solids at the outlet: to check at least 1 time a week their quantity in the Imhoff cone after 2 hours. The maximum value allowed is 2,5 cc.

Water at the outlet: to check its aspect daily, it must be colourless, rather limpid and of almost crystalline transparency. If we note opalescence or turbidity it means that the biological phase has got in some trouble and it is necessary to solve immediately the source of the trouble.

Foam: if the presence of foam is limited to some area of the oxidation tank and its aspect is white, with bubbles of media dimension (cherry), not any kind of intervention is necessary. On the contrary, if the foam is dark, thick, consistent up to form an extended baize, we must rectify it by adding anti foam agents, by the input of bacteria suitable to degradation of surfactants, by oxygen control and thus of the blown air, and by control of the pH value.

Colour: generally does not represent a big problem, but, if in some period there should be a strong presence of colour, near the limit of the law (dilution 1:20 thickness 10 cm) we could intervene with decolourants, to be dosed directly into the sump or into the feed pipe of the decanter (10-50 ppm cationic polyamine or decolorant) or with other products such as hydrosulphite, to be dosed directly into the storage tank.

Feeding: to be maintained constant within the 24 hours and possibly at least 5-6 days a week. For part of Saturday and Sunday, the feed flow to the plant could be limited, reducing the flow which is forwarded by the pumps, or recycling the purified water from the decanter to the head of the plant. But it is very important that during the normal weekly working days, the inlet flow to the plant will be constant, this allows a better distribution of the polluting load, more efficiency of the plant, better use of energy and a more homogeneous ambient for the bacteria and the micro organism, allowing thus a more regular and constant development of the very same.

Observation under the microscope: must be carried out by intervals of 20-30 days checking the consistence of the floc which should be compact and well delineated, absence of suspended bodies between the flocs; the water must result limpid.

The eventual presence of filamentous forms must be attentively valued and if necessary, promptly eliminated by di sodium hypochlorite dosage, into the sump or into the sludge recycling pipes.

Sludge in this form denotes a correct state of the bacterial mass.

Moreover, presence of protozoa of ciliates type such as: vorticella, aspidisca, euplotes, paramecium etc. e rotifers, provide an ulterior confirmation of validity of the process.

Balancing nutritive nourishment: as said before it is advisable to check the COD, TKN, P ratio monthly, which must be equal to 100, 5, 1, if necessary the failing nutrient salts must be dosed.

Mechanical parts: follow the directions of the manufacturer, content in the relative instructions.

Electrical parts and instruments: follow the directions of the manufacturer, content in the relative instructions.

START UP AND MANAGEMENT

Before start up of an activated sludge plant it is necessary to check the following:

- to clean the tanks of all residue accumulated during build up;
- to check the perfect levelling of overflow on the top of the sedimentation tank;
- to check assemblage and functioning of all valves;
- with the diffuser aeration systems, to check the manifolds, the working of the air filter and of the condense traps, the lubrication and the clearance in the compressor, the alignment between motor and compressor, fixing of the motor and the compressor, the performance of the diffusers;
- to start the turbine or compressor and to check the sense of rotation, vibration, noise or abnormal overheating, to measure the power absorption;
- to run the system for four or five hours and repeat the controls more times.

The start up of a activated sludge plant must lead to biological sludge forming within an acceptable time and to stabilisation of a stationary condition of working.

The operation requires the disposability of a workable laboratory, wherein it is possible to analyse the hereafter described.

The proceeding of start up herein described, is referred to a plant equipped with a sole oxidation tank. When there are more tanks in a plant, it is convenient to apply the procedure of start up to one or two of the tanks, the others will be started up by use of the activated excess sludge coming from the preceding.

To accelerate the attainment time of the stationary project condition, during start up, we could apply to use of coagulants on base of ferrous- or aluminium salts, or synthetic organic flocculating agents, which diminish the activated sludge quantity, flown away with the effluent of the sedimentation tank. The dosage of these products must be controlled accurately, to avoid them to reach toxicity thresholds.

Before proceeding to start up, we must take an average sample of the waste water to be treated, we let the suspended solids settle and on the purified we determine BOD_5 and COD, to obtain the COD/BOD_5 ratio: such enables later on to measure less frequently BOD_5 which's analysis require much more time in comparison to those of COD.

Using this ratio, we must take care that it does not change, due to variations of the percentage of non biodegradable material or of flowing away of solids and we must remember that it changes from one section to another of the waste water treatment plant , so it will be convenient to determine the value in different sections.

It is also opportune that the value of such a ratio will be followed during the very first days of start up, until it will be sufficiently constant.

On the fourth or fifth day of start up, if the plant has been started with a good deal of activated sludge or bacteria, the determination of SVI of samples taken from the aeration tank initiates.

SVI is correlated to the sedimentation characteristics of sludge and provides indications about the swelling state of the very same. Sludge having good sedimentation characteristics has $SVI < 120$ ml/g.

To start the process of biological degradation by aerobic micro organism, we could apply either to insemination of activated sludge coming from other plants or wait for spontaneous growth of the proper microbial flora in the oxidation tank. In the second case the average time is more or less 1-2 months, depending on the kind of plant and on the effluent to be treated.

The first method allows to save quite a while in start up. The quantity of insemination sludge must be equal to at least 500 g of suspended solids per m³ liquid in the tank. The supplied air quantity must be such to maintain at least 1-2 mg/l dissolved oxygen in the tank, to allow proper conditions to the growth of the activated sludge.

At the start, the feeding flow must be around 10% of the designed one and should increase 10% every day when the sludge growth normally, or at intervals of major time in case of difficulties in sludge forming.

During start up (in both ways) normally the discharge is null, unless tendency to swelling of the sludge is not revealed, in that case it is convenient to discharge the poor quality sludge and produce new of a better kind. The recycling flow should be such, to avoid that in the decanter a too thick sludge bed is formed or that there will be deficiency of oxygen, in this way all developed micro organism remain the longest possible time in the aeration tank, where they meet the best conditions for a fast growth of the bacterial flora.

During start up, the recycling should be regulated in such a way to respect as well as possible, in every moment and in each running tank the following relation:

$$\text{MLSS of design} \times \frac{\text{current flow}}{\text{flow of design}} \times \frac{\text{current BOD}_5}{\text{BOD}_5 \text{ of design}} = \text{current MLSS}$$

When the required MLSS concentration has been achieved, we let form a thin sludge bed and regulate the discharge flow and the frequency of the very same, so as to maintain a sludge bed equal to 30-60 cm in the decanter. The height should be measured from the bottom near the wall of the decanter.

If the characteristics of the feeding would be much variable, the recycling- and the discharge sludge flow should be changed, so as to maintain the required value of the ratio between feeding and sludge.

By steady state running, the sludge must have good sedimentation characteristics and let a limpid and biologically stable floating.

Until the tenor of solids in the oxidation tank will be low, foam forming will be easier; however we could remedy mechanically, abating the foam by water spraying, or using proper vegetal antifoam agents, not silicone. At the same time, it might be useful, to diminish slightly the air flow. The foam phenomena tend normally to diminish at the increasing of the activated sludge concentration in the tank.

In the enclosed table is reported a sample of a running sheet, containing the relevant data to management of an activated sludge plant; a daily frequency of data survey is advised, with

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exception for BOD_5. Less frequently (for example twice a month), the concentration of volatile suspended solids, nitrogen (ammonic, nitrous, nitric, organic) and phosphorus, at the inlet as well as at the outlet of the plant, must be measured.

By steady state running, to check the suspended solids concentration in the aeration tank we must act on the sludge's age (i.e. on the discharge flow of sludge): generally it is possible to maintain an aerated mixture with 4-8 g/l suspended solids in the tank (provided that a proper aeration capacity will be available).

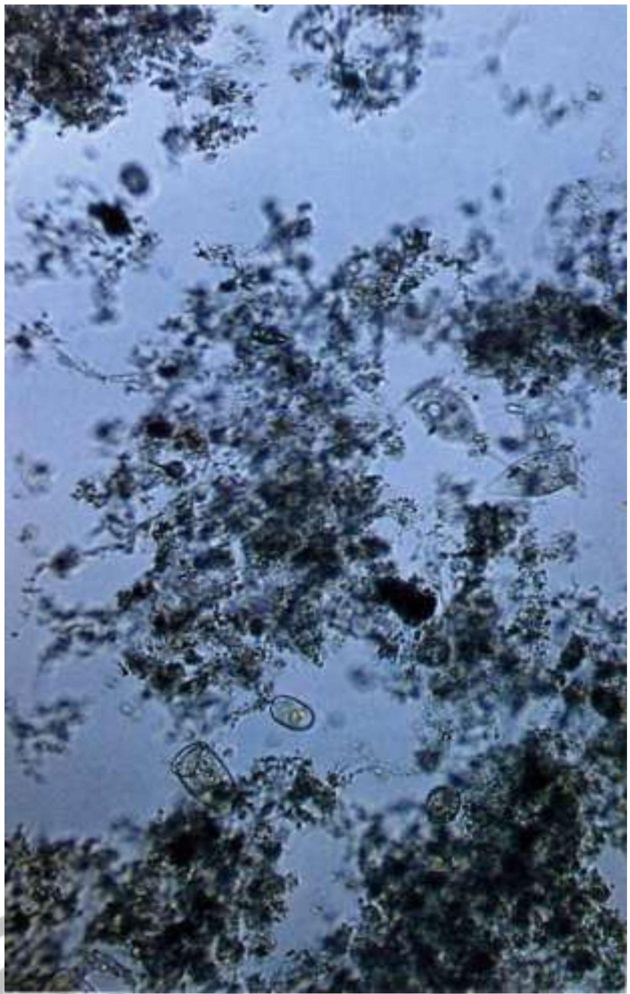
To check the retention time of the sludge inside the decanter, we will act on the recycling ratio: too low values of such parameter could provoke septicity of the sludge, on the contrary, too high ratio, could cause too light and too bulky sludge (as in the decanter the available time for sludge thickening will become too short).

1) THE ACTIVATED SLUDGE

Three are the principal causes responsible for good or bad running of an activated sludge plant:

1. The technical quality of the plant and the degree of use.
2. The characteristics of the waste water.
3. Management and maintenance of the plant by the staff.

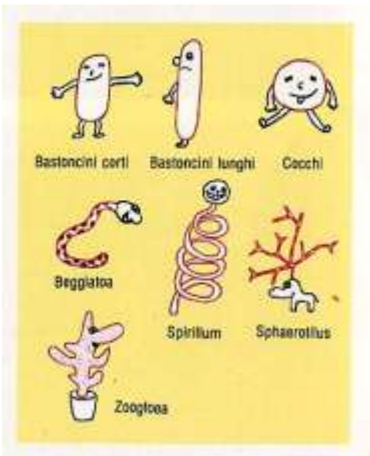
The activated sludge, in many cases, supplies by itself information about how much have to be valued favourable or unfavourable the above main causes.



SLUDGE UNDER THE MAGNIFIER

A glance on the microscope shows us that the activated sludge presents a community of life, made up by lots of different organism; now we are going to know the most important.

BACTERIA



Bacteria are the most important and at the same time smallest living beings in activated sludge. They could reach the number of many milliard (billion) a litre.
Their size, mostly, reaches thousandth or hundredth of a millimetre. Although bacteria are having multiply shapes, there are related kinds which are, mostly, so alike to be difficult to be recognized on the microscope.
Most of the specimen can be distinguished only based on their metabolism characteristics: for example by capacity of converting well defined organic substances into others.

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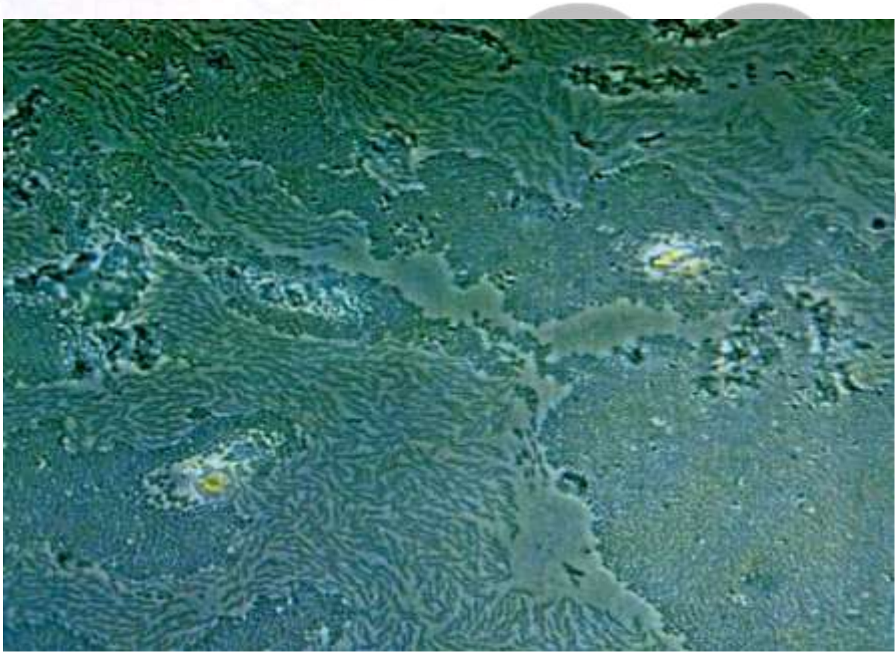

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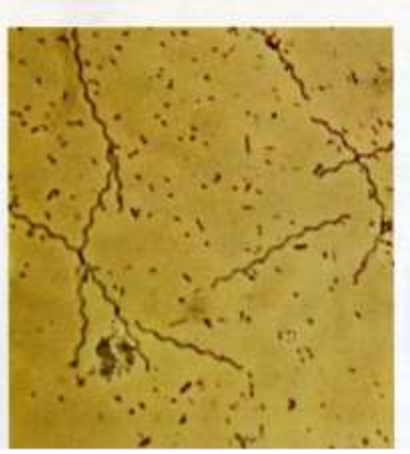
BACILLI(5)
Most of the bacteria specimen are stick shaped more or less long.
Many are practically immobile.
Others are able to move quickly with assistance of subtle flagellum filaments.

At the time of reproduction by scission, the immobile specimen constitute more times colonies of average structure or of a great ornamental effect (6).

SPIRILLUM (7)
The spirillum assume their name from the Latin term spirillum, not only due to their shape but even to their characteristic spiral movement, the rotation is mostly so quick that the spirillum become to be invisible to the naked

eye in the imagine on the microscope.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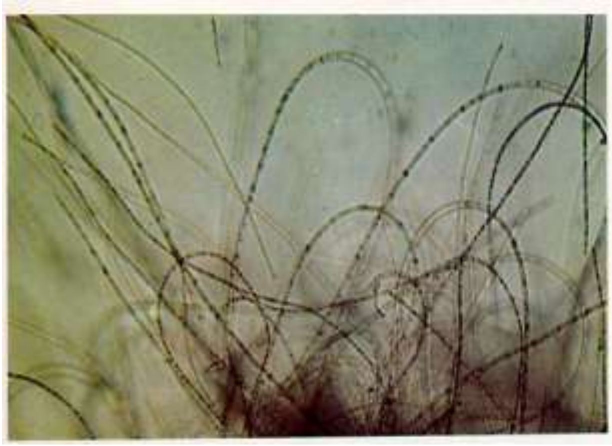
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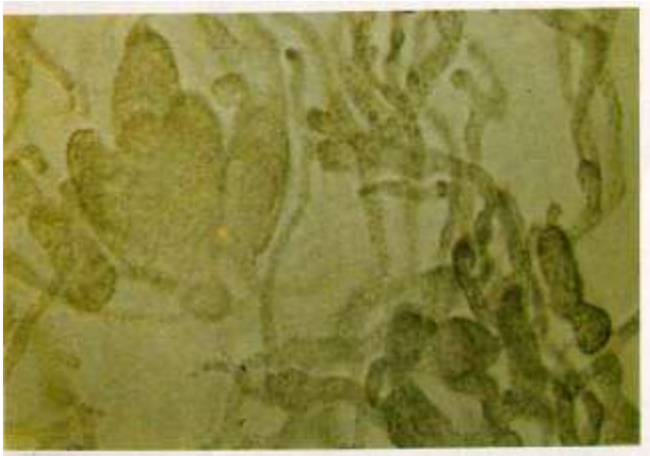
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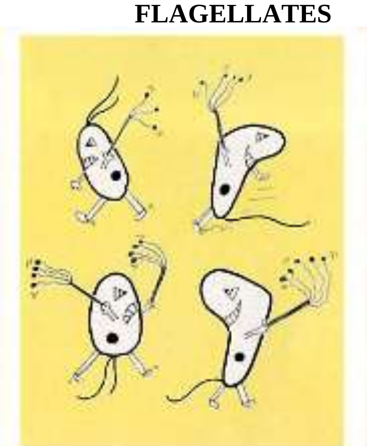
VITREOSCILLA (8)
Remarkable bigger and long spiral shaped, are bacteria of the Vitreoscilla specimen. Contrary to spirillum these move crawling; the movement is but so slow that it is hardly perceptable.

SPHAEROTILUS (9)
A quantity of bacteria constitute filamentous colonies.
The Sphaerotilus which we can observe in this imagine, has fixed filaments, apparently ramified, without movements by its own.

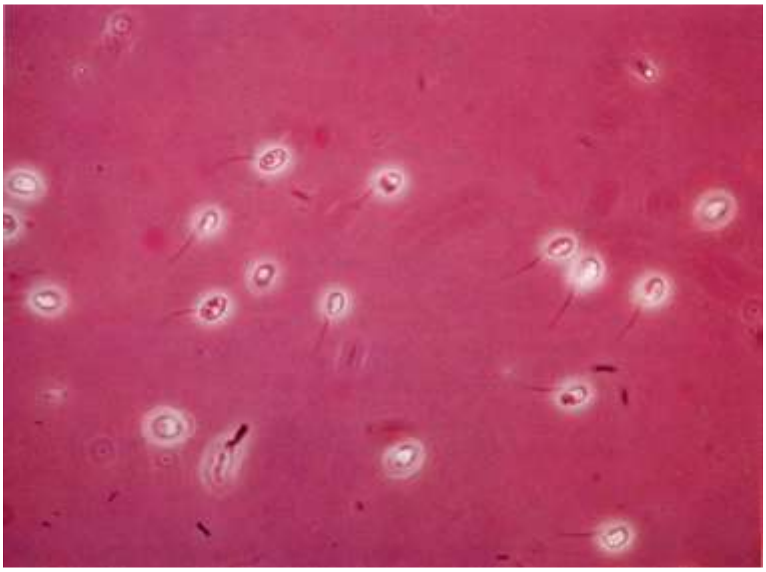
BEGGIATOA (10)
Not ramified, but characterized by crawling movement, is the sulphobacteria Beggiatoa. The grains which refract strongly the light, situated inside of the unramified filaments, are small sulphur drops.

ZOOGLOEA (11)
Bacteria from the Zoogloea family constitute bizarre ramified colonies tree shaped also called “Zoogloea ramigera”.

FLAGELLATES

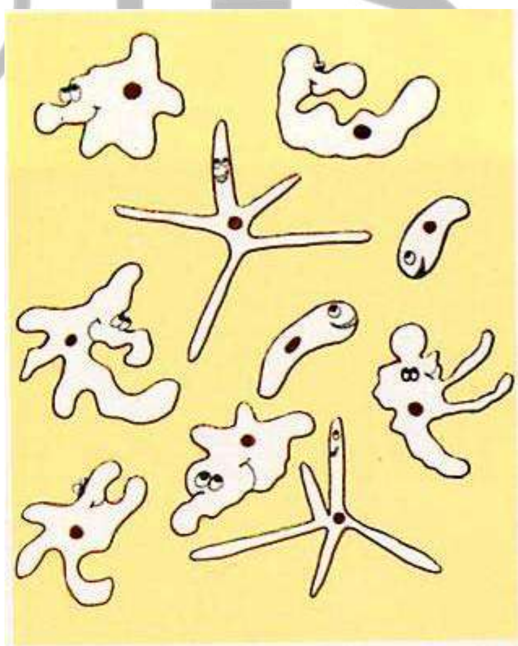


The flagellates are situated at an intermediate position between the animal- and the vegetal world.
Medially greater than bacteria, most of these monocellular beings reach hardly the length of a twentieth of a millimetre. These organisms owe their name to presence of one or more mobile flagellum filaments, which with their motion allow the organisms to move.

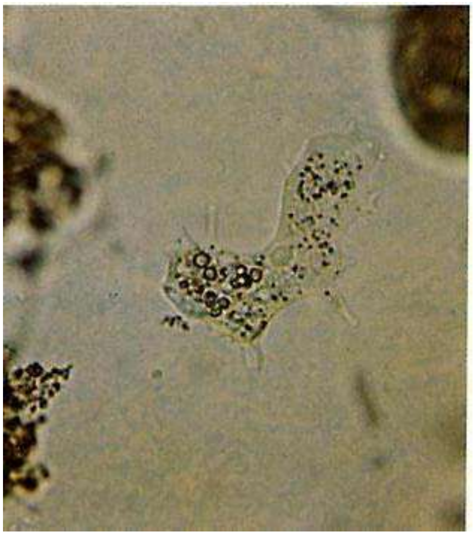


The flagellates can reach a density of several million per litre. Due to their reduced dimension, their determination is very difficult.
Mostly the flagellates, are visible on the microscope only at a dark field or at illumination in phase contrast.

AMOEBAE



The name amoebae from Greek "amoibé" which means transformation, derives from the typical capacity of these organisms to change incessantly their shape.
In the same way, the different specimen show, at the moment of their crawling-fluctuating movement, a clean difference in the momentarily forming of the corporeal appendices, the so called pseudopods The smallest amoebae hardly reach the length of a hundredth of a millimetre; but there are specimen comparatively enormous in length which exceed a millimetre and which can be seen with the naked eye.

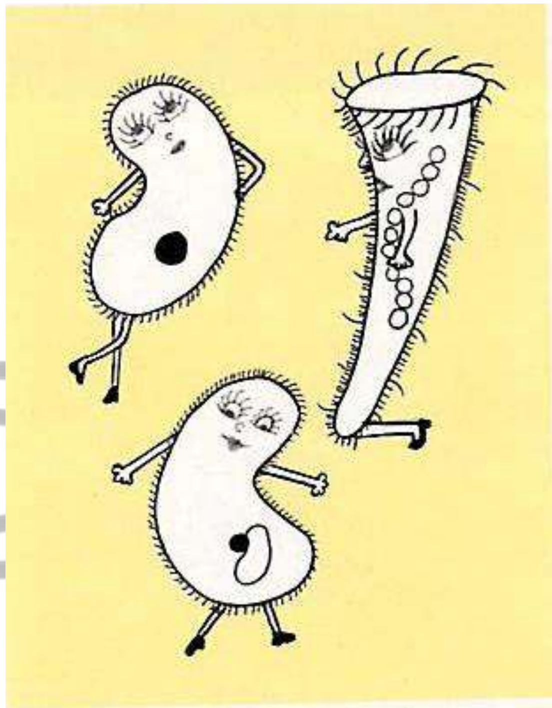


VAHLKAMPFIA (15)
The smallest amoebae can be found in the Vahlkampfia specimen. At the moment of their shift they form with difficulty pseudopods; their contour is therefore not much variable.

MAYORELLA (16)
In the Mayorella specimen we note numerous, but short pseudopods.

ARCELLA (17)
Some amoebae have around their body shell shaped involucres , just as this small animal of the Arcella specimen.

CILIATES



The ciliates constitute the most multiform of the orgasm present in activated sludge.
Although these are apparently also monocellular living beings, their internal structure is rather complicated and highly developed, more than the specimen of groups which we were talking about up till now.
The external surface of the ciliates is covered with many cilia shaped plasmatic protuberances, from which derives their name.
With the help of their cilia, these beings attract food and move.

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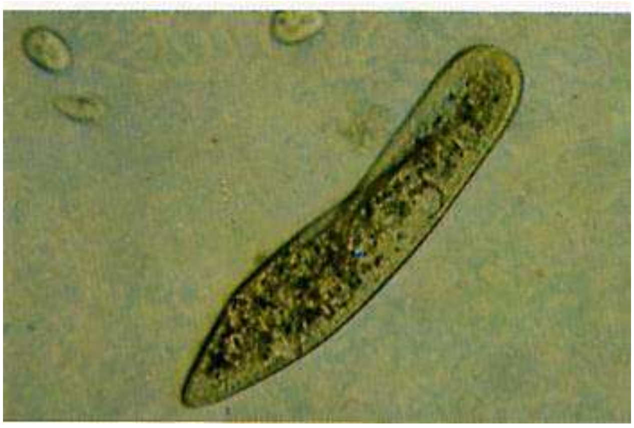
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PARAMECIUM CAUDATUM (19)
Among the ciliates we find a specimen of rather big dimensions (ca. 1/3 mm length): we are talking about the protozoa Paramecium Caudatum.
Due to its capacity prone to proliferation in an infusion of hay, this little being is very popular in the field of the biologic teaching and is definitely the most popular among all other microscopic living beings**.**

STENTOR MOLITOR (20)
Even much bigger are the represents of the Stentor family which in fact reach an exceptional length up to one and a half millimetre. The Stentors are characteristic for their corporal shape which recalls that of a microscopic trumpet.

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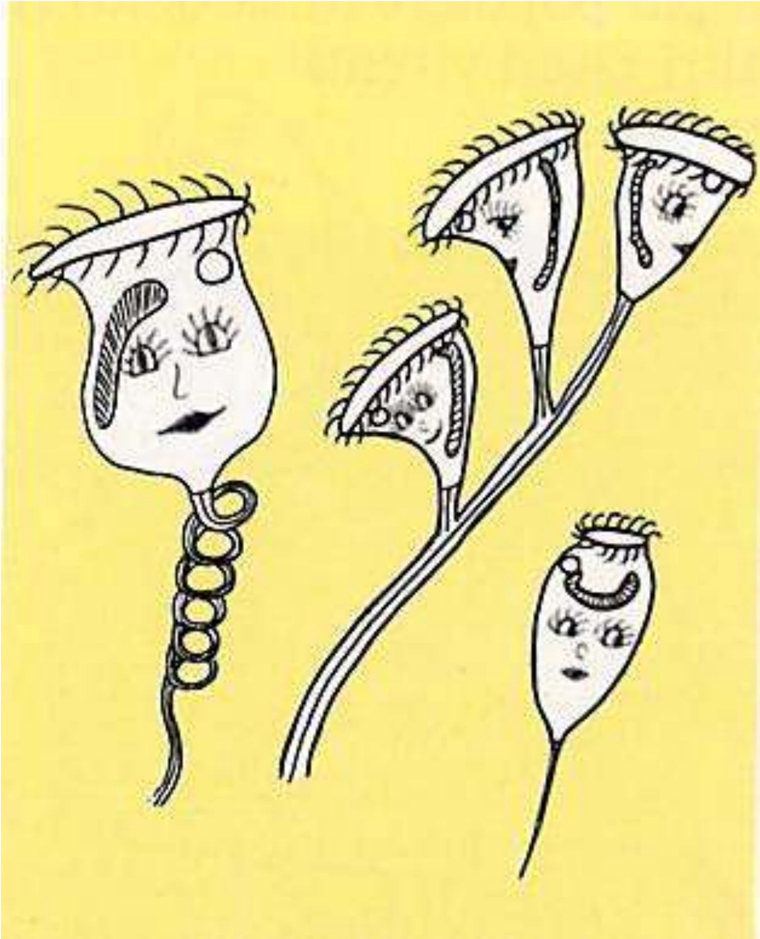
VORTICELLE



A particular position in the group of ciliates have the vorticella.
Mostly they are chalice shaped beings, with a ciliated edge and supported by a stalk which adheres to the substratum. They have immediately a remarkable involution as concerns their ciliated mantle.
The remaining is connected to a small spiral shaped ciliated crown, which is situated around the oral opening; this, due to whirlpool forming, attracts the food.
In determined circumstances a second ciliated crown is formed, which confers on the small animal the capacity to abandon the stalk to which he is connected and to move by swimming. The stalk of many vorticella are endowed inside with a likewise muscular fibre: the so called myonem.
Due to this organ the stalk has the capacity of shortening, forming a small spiral in a fraction of a second. By means of this movement these beings, which by themselves are bound to support, are able to avoid still certain dangers.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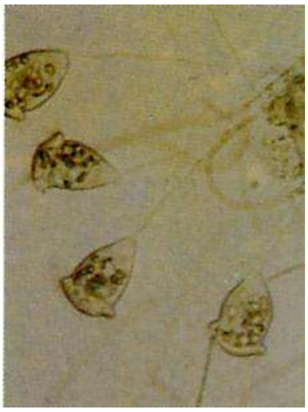
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CARCHESIUM POLYPINUM (22)
The Carchesium kind is easily reckognizable for its ramified and retractable stalk. The colonies may count more than thousand individuals and reach quite a lot of millimetres.

VORTICELLA (23)
The protozoa from the vorticella family have a single stalk, not ramified, endowed with myonem.
The picture shows an example of the Vorticella - convallaria specimen.

EPISTYLIS (24)
Other specimen, such as the Epistylis illustrated here above, do not possess any myonem: thus their stalk is rigid and immobile.

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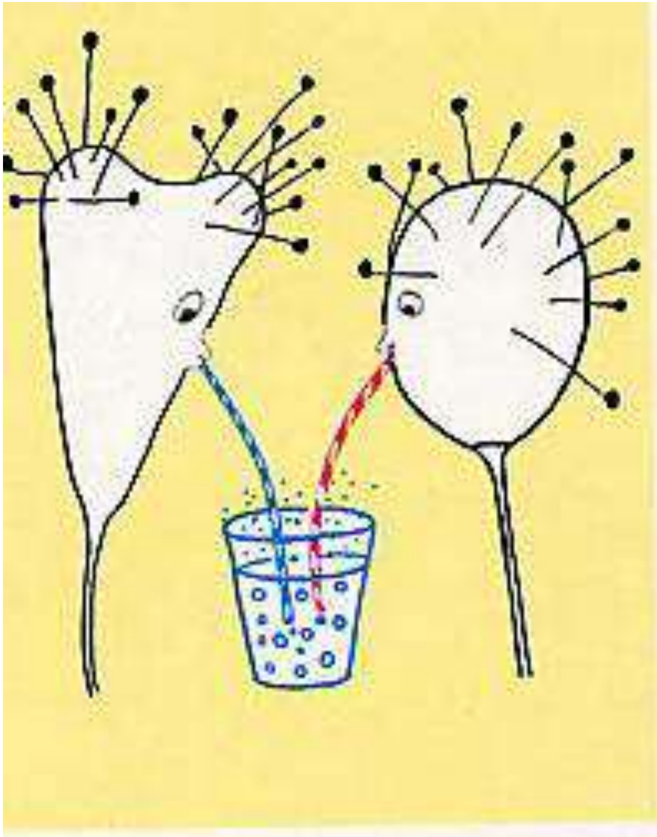
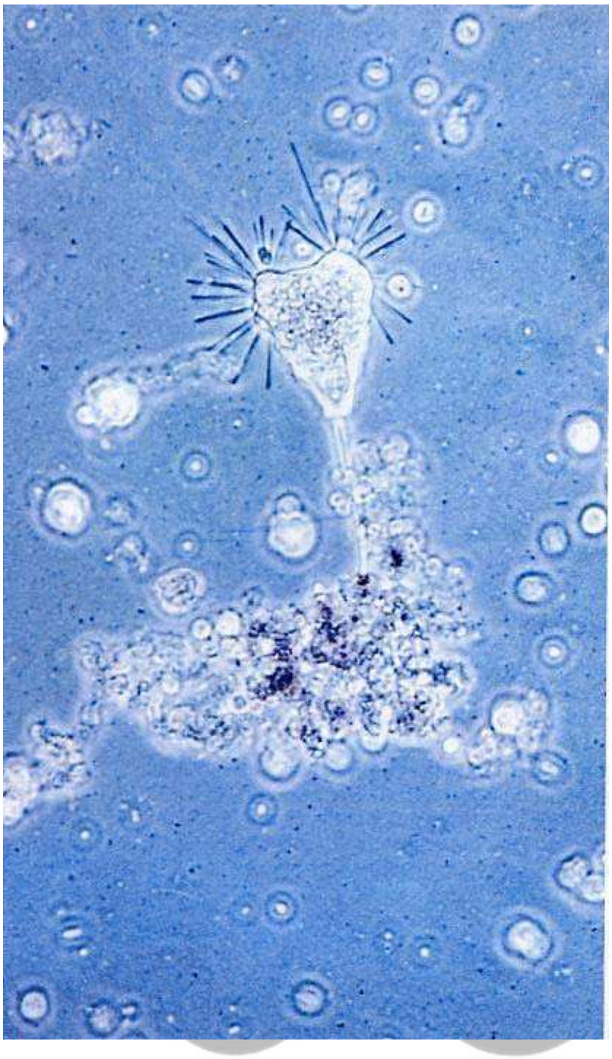
THE INFUSORS



The infusors or suttors are practically the nearest parents to the ciliates.
Instead of mobile ciliates these have rigid small sucking tentacles with a small thickening at the end.
For many infusors the small tentacles are bundled.
Most of the infusors are having a stalk, but without myonem.

26 

TOCOPHRYA (26)
In case of these Tocophrya we can observe two bundles of small staks.
Other represents of this family could have four.

ROTIFERS

On the opposite of all organisms we talked about up till now, rotifers are real and proper multi-cellular beings, even if the represents of this family are only just a little bigger than ciliates.

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This specimen owes its name to a small organ with which its represents are endowed. At the moment of observation on the microscope, the human eye has the impression to see rotating toothed wheels; the organ concerned has in fact a particular whirling conformation.

ROTARIA

In the organisms of the rotifer group this whirled organ distinguishes itself in a particular way.

Microscopic observation

During operating, it might be very interesting to carry out desultorily microscopic observation on the characteristics of the sewage and the sludge, which are able to supply useful elements about the working of the plant.
These observations assume particular signification in biological plants, as for the great variety of micro-organisms easily distinguishable with a microscope even with magnification rather reduced, and the indications which can be drawn of their observation. In fact, depending on the available food quantity and of the particular ambiental conditions, (temperature, dissolved oxygen concentration, characteristics of the waste water to be treated ...) develop prevailing forms of micro-organisms making up an «ecosystem», regulated by complex equilibrium

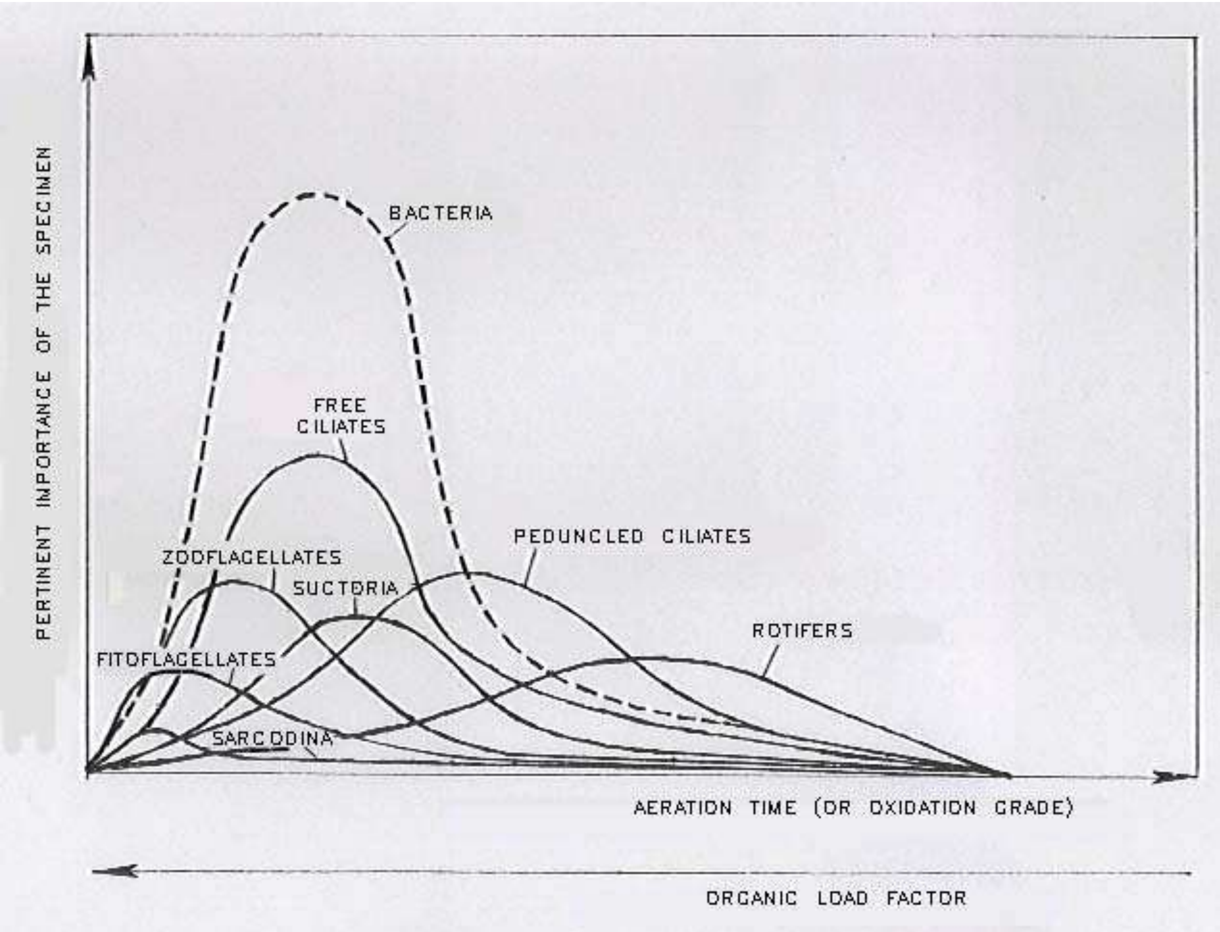

Fig. Relevant importance of di various micro-organism species present in biological waste water treatment plants, particularly in activated sludge plants, at variation of the oxidation ratio and the organic load factor.

The basic element, fit for determination of the prevailing types of micro-organisms, is the organic load «F_c» factor; it is in fact understood, that, at variation of the food/micro-organism ratio, quite different conditions are stabilized: at a low ratio of the «F_c» factor, the most resistant forms will be

prevalent; in a competition fight during scarceness of nourishment; on the contrary, at an elevate «F_c» ratio, will prevail those micro-organisms which, in abundance of food, are endowed with the maximum food assimilating and reproduction capacity; since at elevate «F_c» ratio correspond low sludge age value, those superior organisms will be absent (for ex. the rotifers, see the following), which grow slower, pertinent to retention time in the system. Great importance on the contrary are having the protozoa , as they are typical predatory which, feeding on micro-organisms even isolated in the liquid mean (particularly of dispersed bacteria), contribute in a remarkable measure to improve the limpidity of the effluent. Absence of protozoa in the activated mass of the aeration tank, correspond always to an effluent of bad quality.
Significant, from qualitative point of view, is the graph of Fig. 9 which individuates the prevailing types of micro-organisms («microfauna»), besides the bacteria («microflora»), at variation of the «F_c» factor(or of the aeration time).
In Fig. 10 have been quoted some of the most characteristic type of micro-organisms, referred to in the graph examined before.
The exam of the microscopic characteristics of the activated sludge of a plant, is particularly useful, as the predominance of certain types of micro-organisms on others, not only is characteristic of the type of plant and the load on which it works, but may constitute an index of good or bad performance. Fig. 11 gives an idea of the order of sizes of the various elementary units which intervene in an activated sludge process.
For the microscopical exam of the singular bacteria, of sufficient details, very big magnifications are necessary, and the most suitable instruments are electronical microscopes .
The bacteria present in activated sludge are very numerous (Zooglea, Flavobacterium, Pseudomonas, Mycobacterium ...). The major part are *facultative*.
Such demonstrates the motivation for which an activated sludge could resist even 24 hours, with the aerators out of order, without particular diminishing of vitality of the bacteria. On the contrary, the superior organism hereafter examined suffer it very strongly and also the settleability of the sludge.
The concentrations are between 10^{11} and 10^{12} unit/liter.

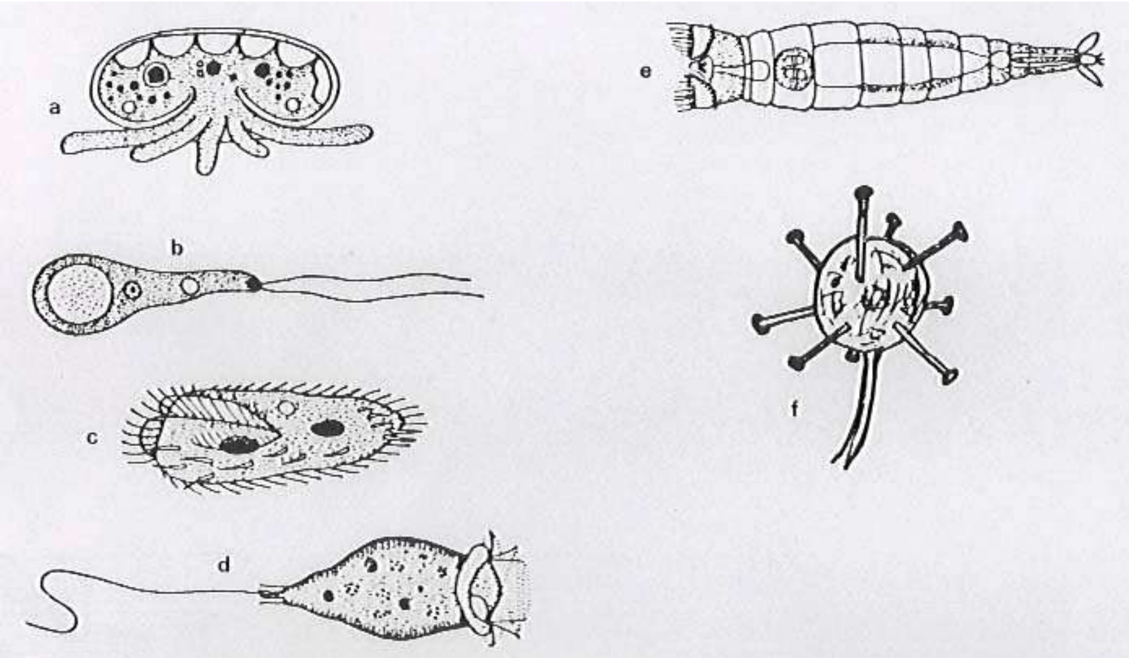

Fig. 10 Various types of micro-organisms present in biological waste water treatment plants. a) Sarcodina; b) flagellate protozoa; c) free ciliate protozoa; d) peduncolated protozoa; e) rotifers; f) Suctoria .

A) COAGULANTS AND FLOCCULANTS [2]

Aluminium sulphate

Formula $Al_2(SO_4)_3$ Molecular weight 342.
It is commercialised in hydrated form with formula $Al_2(SO_4)_3$ x nH_2O, where n is variable between 11 and 15 in powder or granular form.
The title is characterised by the concentration in weight of Al_2O_3 , which never descends below 15÷17%.
It is commercialised also in watery solution, with title 6 ÷ 8% of Al_2O_3 in weight.
The typical reaction in the chemical treatment of flocculation with the alkalinity of water, is the following:

bicarbonate present in water

$$A1_2(SO_4)_3 + \underline{3Ca(HCO_3)_2} \;—\; 3CaSO_4 + \underline{2Al(OH)_3} + CO_2$$

precipitates and acts like flocculent

The optimum pH field, in which the action of the product is best, is between 5 and 7.
In case of scarce alkalinity, adding the product to the water together with lime, the reaction is the following:

lime added

$$A1_2(SO_4)_3 + \underline{3Ca(OH)_2} \;—\; 3Ca(SO)_4 + \underline{2Al(OH)_3}$$

precipitates and acts like flocculent

In powder or granular state, aluminium sulphate can be held in cement, iron, plastic containers; in solution, manifests an acid reaction, and is aggressive to metal. Thus, for storage, ebonite or PVC coated iron, glass-polyester combination, cement, coated with epoxy resin, PVC or polyethylene, is adopted.
For pumping of the solution, pipes and pumps in anti-acid and corrosion resistant materia, are necessary.

(1) Much more detailed information about the characteristics of the various products, such as their specific weight, solubility in water, inconvenience they might produce, danger and particular caution connected to manipulation will be available directly at the manufacturer's and the retailer's.

(2)The same reagents are utilisable in chemical precipitation of phosphorus.
Particular precautions requires also the manipulation of solution (rubber gloves, aprons, goggles are necessary), as, for its acid characteristics, it could provoke instantaneous smart to the eyes and mucous and after a few minutes, smart of the skin which had come into contact. It is necessary to wash with lots of alkalinised water (with bicarbonate) or with water and soap.

Ferric Chlorosulphate
Formula $Fe_2(SO_4)_3 + FeCl_3$.
It is a mixture of sulphate and ferric chloride in molecular ratio 1:1, achieved by causing reaction of ferrous sulphate and chlorine, as by the following reaction:

$$6\ FeSO_4 + 3Cl_2 \longrightarrow 2\ Fe_2(SO_4)_3 + 2\ FeCl_3$$

In commerce it is available, in watery solution at 10% in weight of Fe^{++} equal to 14% in weight of Fe_2O_3. It is a good coagulant-flocculent in the chemical treatment of sludge, summing up the characteristics of sulphate and ferric chloride; it is efficacious in a field of pH ratio between 6 and 11,5; the most favourable conditions are achieved for pH higher than 8.
It has an acid reaction so, for storage, pipes and pumps, anti-acid material, analogue to that utilised for aluminium sulphate solutions is required.
Analogue are the precautions to be adopted in case of accidental contact.

Ferric chloride
Formula $FeCl_3$- Molecular weight 162.
It is commercialised in hydrated form, normally as $FeCl_3$ x $6H_2O$.
It is available in watery solution, at 40% in weight of $FeCl_3$, or in solid granular form (crystals) at 60% in weight of $FeCl_3$ (eptahydrate ferric chloride).
In case of scarce alkalinity of water, the product can be added to the water together with lime, with reaction quite analogue to that seen for aluminium sulphate.
Along with aluminium polychloride, it is without any doubt one of the best flocculents for waste water; having the advantage that its flocculent action is little influenced by the pH of the water.
The typical reaction of ferric chloride as flocculent is the following:

bicarbonate present in water

$$2FeCl_3 + \underline{3Ca(HCO_3)_2} \longrightarrow 3CaCl_2 + \underline{2Fe(OH)_2} + 6CO_2$$

precipitates and acts as flocculent

In dry state it is not corrosive; in watery solutions, it has an acid reaction and is aggressive to metal. For storage, pipes and pumps, anti-acid material, analogue to that utilised for aluminium sulphate solutions, is required.
Analogue are the precautions for manipulation e in case of accidental contact.

Aluminium polychloride (PAC)
It is going about a polymolecular complex product of the general formula:

$$Al_n(OH)_mCl_{3n-m}$$

For example, one form is:

$$A1_2(OH)_4Cl_2$$

In commerce it is available in watery solution; the title is characterised by concentration in weight of Al_2O_3; the minimum title is 10% of Al_2O_3.
It is commercialised under diverse names (Alpoclar, WAC, Prodefloc...).
It is used as coagulant-flocculent for chemical treatment of sludge; its coagulant action is little influenced by the pH and explicates well in field between pH 5 and pH 10; its flocculent action does not require interaction with the alkalinity of the water: for this particularity, the product has characteristics even better than ferric chloride.

It has an acid reaction, so for storage, pipes and pumps, anti-acid material analogue to that utilised for aluminium sulphate solutions, is required.
Analogue are the precautions for manipulation and in case of accidental contact.

Ferrous chloride
Formula $FeSO_4$- Molecular weight 152.
Normally presents in eptahydrate form, with formula $FeSO_4$ x $7H_2O$.
It is commercialised in granules with title 18 ÷ 20% in weight of Fe^{++}. It is used as flocculent for chemical treatment of sludge and for sludge conditioning.
In water, for hydrolysis, ferrous hydroxide forms, which oxidises to ferric hydroxide, provided that in the water a sufficient quantity of dissolved oxygen exists: ferric hydroxide is indeed the product which consents a real efficient flocculating action, and thus, if there is a not sufficiently elevated oxygen concentration in the water, it is necessary to provide for artificial aeration.
And thus particularly indicated in processes of dephosphating for simultaneous precipitation, being possible to put it directly in the activated sludge aeration tanks.
The optimum pH field for an efficacious reaction of the product, is between 8,5 and 11. The typical reaction of ferrous sulphate as flocculent is the following:

bicarbonate present in the water

$FeSO_4$ + $\underline{Ca(HCO_3)_2}$ ——— $Fe(OH)_2 + CaSO_4 + 2CO_2$

$2Fe(OH)_2$ + $\underline{O}$ + H2O ——— $\underline{2Fe(OH)3}$

acts as flocculent

dissolved oxygen present in the water or artificially added

It is a by-product of the iron pickling operations and of production of titanium dioxide. Suitable materials are the same seen for aluminium sulphate and the same precautions seen for this product are worthwhile.
It is convenient to put the product in powder into solution, as soon as it had been received, to repel attack of humidity.

Polyelectrolyte
They are organic macro-molecular (polymers) compounds produced from either natural products (alginates, starches ...), or entirely synthetic.
Ones in suspension in water, it supplies colloidal solutions, which's molecules (for anionic and cationic types), are electrically charged; they are classifiable in three categories:

A) *Anionic*, essentially polyamides in carboxylic groups substituted with negative charge, or with molecular weight equal to 2-10 million.
B) *Non ionic,* without charge, polyacrylimides or derivatives of starch, molecular weight 1 million and more.
C) *Cationic*, with positive charge, cationic derivatives of starch or of acrylamides, molecular weight 1-1,5 million.

The variety of the commercial products is ample and continuously new products are formulated. They are available in watery solutions in emulsion form, with title of 20-30% activated substance, or in solid state as powder, normally commercialised in water proof sacks.
The type in watery solution tends to be used more in plants of small - medium potentiality, for its major simplicity of dosage.

Normally non resist to chlorine and thus they can not be used in concomitance or after a chlorination process.
The life of the product is limited from 10 months till 2 years, depending on the type.
They are used as flocculents for chemical treatment and conditioning of sludge, alone or as auxiliary of coagulation of inorganic flocculents; in this second form, they are particularly suitable for chemical treatment of sludge, whereas for treatment of sludge, they may also be used individually.

Anionic types, are more suitable for individual chemical treatment of sludge of organic character; the cationic types suit well in combination with inorganic coagulants.
For sludge conditioning, previously cationic types are used.

In solid state, polyelectrolytes are not corrosive; on the contrary, in watery solutions, they could manifest corrosive action against aluminium, copper, zinc and pertinent alloys: particularly zinc results attached and thus use of galvanised material in contact with the products is to be avoided. AISI 304 e 316 iron resist well.

It has nothing to do with particular dangerous products, anyway, contact with the eyes could provoke irritation, and should it be the case, it is necessary to provide immediately for prolonged washing; also frequent and excessive contact with the skin must be avoided.

B) OXIDANTS AND DISINFECTANTS

Chloro gas
Formula Cl_2. Molecular weight 71.
It has very toxic characteristics: 30 mg/l di Cl_2 in the atmosphere are enough to cause death.
So transport, storage, use, require specific authorisation and *very particular* precautions.
It is indispensable to instruct in details the assigned personnel, about various risks connected to utilisation of chloro-gas, and to equip the plant with all the necessary devices (automatic detectors of chlorine with alarm, anti-gas masks, protective clothing...) supplying the operators with all necessary information about behaviour to be adopted in case of accidents and gas leakage. The chloro-gas is utilised principally for disinfecting of water and may also be used for chemical stabilisation of sludge, besides whereas generally its oxidising capacity can be exploited.
It is supplied in:
- cylinders, generally with a useful load of 50 kg;
- big cylinders, generally with a useful load of 500 and 1000 kg.
In pressured containers, the liquid and gaseous phase and the saturated state (steam) co-exist: in fact, chlorine liquefies at 40 °C by pressure of 10 atm, and at 18 °C by pressure of 5 atm.
Under gas form in dry state (or rather even in liquid state but without presence of water) metal and usual alloys resist chlorine.
In the humid gaseous state, minute traces of humidity are sufficient to provoke corrosion on metal and the current alloys; only lead resists efficiently.
Ebonite coated iron, glass, sandstone, porcelain, glass-polyester combinations are used.
On the contrary, epoxic glass fibre combination does not resist.

Calcium hypochlorite
Formula $Ca(OCl)_2$- Molecular weight 143.
Normally presents in hydrate form, with formula:

$$Ca(OCl)_2 \times 4H_2O$$

In commerce it is available in granules, powder, in tablets, with tenor in activated chlorine variable from 55 to 70%.
In solid state, it is stable if stored dry; it deteriorates quickly in humid surroundings.
It melts easily in water, and in solution it has characteristics of elevate aggressiveness, before all regarding ferrous material.
To contain it, sandstone, ebonite coated or with polyvinyl chloride coated iron or cement, or with polyethylene or epoxic resins or glass-polyester combination, are suited.
For the pipes, those in sandstone and in polyvinyl chloride, PVC, nylon, polyethylene are suited.

Sodium hypochlorite
Formula NaClO. Molecular weight 78.
In commerce it is found in watery solution; it is individuated according to the «activated chlorine title». For «title» or «tenor» in activated chlorine the tenor in elementary chlorine is intended.
Two types of sodium hypochlorite are existing:
- hypochlorite at 12-13% in volume of activated chlorine, equal to about 10% in activated chlorine weight;
- hypochlorite at 18-19% in volume of activated chlorine, equal to about 15% in activated chlorine weight;

It is quickly degradable, the more, as the solution has the more an elevated title.
Particularly noxious is the light, and therefore storage must always occur in opaque vessels, eventually having recourse, in case of glassfibre containers, to covering paint.
Suitable materials are the same seen for calcium hypochlorite.
It is necessary to pay particular attention to manipulation of this product, by using rubber gloves, goggles, protective clothing; in case of direct contact, burn of the skin, the eyes or mucous might happen: in that case, it is necessary to wash abundantly with water, for several minutes. *Never* put the product in a vessel in which acid products, such as aluminium sulphate, ferric chloride, aluminium polychloride were kept before.... as hypochlorite reacts violently!!!

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C) VARIOUS

Lime

It is available under oxide form CaO (quick lime), molecular weight 56, or under hydrate form $Ca(OH)_2$ (hydrated lime), molecular weight 74. From quick lime, by reaction with water, hydrated lime is obtained.

Quick lime is commercialised in powder, granules, lumps (in sizes of 10 ÷ 15 cm); hydrate lime is quite always commercialised in powder. The title in CaO of commercial quick lime, is variable between 93 and 98%; the title in CaO of hydrate lime is between 72 and 74%; the rest is made up by impurity and chemically combined water.

Normally, in small plants, hydrated lime is used, as because quick lime requires slacking, which is a delicate operation and cause of complication in performance.

Particularly dangerous for the operators are squirts on the skin and in the eyes: it is necessary to wash *immediately* with water for some minutes.

The dosage occurs by preparation beforehand in the form of suspension *(milk of lime);* to achieve a real and proper solution (*lime water),* the dilution normally is too high .

The maximum solubility of lime is 0,18 gr/100 at 0°C, and 0,15 gr/100 gr at 30°C. Lime is used in chemical treatment of sludge, alone as a flocculent and for precipitation of phosphorus compounds (in such a case, one operates at a very high pH) and as corrective of pH, along with other flocculating reactives.

Along with other flocculating reactives, it is used pure for chemical sludge conditioning.

It is also used for chemical sludge stabilisation.

Lime is not aggressive against various materials and does not present particular problems of storage, if the ease of lime in powder state, to «stick together» and render difficult backflowing from the opening of the vessel, will be excluded.

Sodium carbonate

Formula Na_2CO_3- Molecular weight 106,0.

It is commercialised in pure state as white powder at 58% of Na_2O; it is an high reactive alkaline product, used for correction of the pH. It finds application in the alkalinisation of sludge in anaerobic digestion. Suited material for manipulation are plastic, iron and steel, rubber.

It is transported in sacks, in barrels or loose.

Sodium metadisulphite

Formula $Na_2S_2O_5$- Molecular weight 190,1.

It is in commerce in white powder form, with tenor of SO_2 of 62%. It exercises a potent reducing action, thus it is used for dechlorination of water, and for de-oxidation in the final tests of the aerators. It is slightly acid and hygroscopic; suited for manipulation are plastic and ceramic, glass, lead and rubber.

Sulphurous acid

Formula SO_2- Molecular weight 64,1.

It is a colourless gas, normally commercialised in cylinders of 50 lt. It exercises a potent reducing action and is used above all for dechlorination. Dosage is carried out with equipment completely analogue to those used for chloro-gas. Suited for manipulation are plastic, glass, lead, nickel, rubber.

Caustic soda
Formula NaOH. Molecular weight 40,0.
It is commercialised in form of white flakes at 76% of Na_2O, or in form of liquid solution at 50% of NaOH. It is a reagent at very high alkalinity, used for la correction of the pH of water. The solid product is hygroscopic. Either in solid form, or in solution, in contact with air it is subject to deterioration by carbonatatation (CO_2 of the atmosphere).
We have to do with a *very dangerous* product, which's manipulation requires *particular precautions* from the assigned personnel's side (protection of the eyes with goggles and of all parts of the body with suitable clothing); in case of accidental contact, prolonged washing with slightly with acetic acid acidified water is necessary. In the case in which the eyes are involved, the washings must be prolonged for at least one hour.
For the product in solution, material such as plastic, cast iron, rubber, iron are useful. The solid product is normally transported in drums; liquid in barrels, or loose (with tankers or railway tankers).
Storage of the solution must be carried out in a heated room to avoid crystallisation of the product.

Sulphuric acid
Formula H_2SO_4- Molecular weight 98,1.
A reagent with very high acidity, used for correction of the pH of water.
It is commercialised in liquid form, in concentration of 93% or less. In concentrate form, it is very hygroscopic and presents *serious danger* for the personnel, requiring all attention seen for caustic soda.
In concentrated form it can be manipulated with material such as iron, steel, lead, glass, ceramic, plastic, rubber; in diluted form, it is highly corrosive against iron and steel and must be manipulated only with material such as plastic, rubber, glass, ceramic, lead. It is transported in barrels or loose (with tanks or railway tanks).

USE OF SLUDGE IN AGRICULTURE

9.1.APPLICABILITY AND LIMITATIONS
Accordingly to the ecological import of biological waste water treatment plants, the last destination of the produced organic sludge can not be else than agricultural use, the only way of recycling and reuse of the contained substances. As we will see here below, for the tenor of organic substances and fertilizers (N, P_2O_5**,** K,O) use and agricultural value of sludge are similar to those of manure.
The practice of agricultural use of sludge has diffusely been applied for a long time in the USA and in many European countries.
We can list in Table 1 the positive and negative factors which come into play in agricultural use of sludge and its limitations.

Table 1 Positive and negative factors in agricultural use of sludge

Positive factors	***Negative factors***
- Economy in sludge dumping	- Risk of infection
- Amending effect	- Risk of immission of substances which damage the ground; the cultures and human.
- Fertilizing effect	- Risk of smell
- Humidifying effect	- Risk of contamination of the stratum and the ground water

We advise to contact chemical analysis laboratories and to analyze the biological sludge before using it in agriculture.

FERTILIZING VALUE OF SLUDGE

In view of their dump and their possible agricultural use, it is opportune to consider the chemical composition of sludge before each single technological treatment: at this regard variation of the di nutrients content, N, P, K, Ca e Mg reported in Table 2 is significant

Table 2 Macro-nutrients content in sludge after the pertinent treatments (indicative value range expressed in percentage of dry)

Kind of sludge	N_{tot}	P_{tot}	K_{tot}	Ca_{tot}	Mg_{tot}
Primary	2,1-7,6	0,6-3,0	0,1-0,7	1,4-2,1	0,6-0,8
Secondary	3,8-7,6	1,2-3,2	traces	0,5-0.8	0,5-0,8
Mixed raw	1,0-6,5	0,6-2,5	0,1-0,7	< 2	< 0,8
Liquid mixed digested	0,9-6,8	0,5-3,0	*0,1-0,5*	1,5-7,6	0,3-1,6
Naturally dehydrated	1,5-2,5	0,5-3,0	0,1-0,3	1,6-2,5	0,1-0,4

First of all we note the higher N and P content of secondary sludge compared to the primary, but most of all the elevate richness in nitrogen in the liquid phase, evidenced by the fall per cent between liquid mixed digested sludge or and mixed dehydrated. Such is due to ammonification of organic nitrogen and the pertinent solubilization, in the liquid phase, during the biologic stabilization process: analogue fall verifies in sludge treated with lime, which provokes volatilization of ammonia. Such a fall seems not to be as much sensible to phosphorus as it is present in almost the totality in insoluble form because it is connected to iron, aluminium, calcium and magnesium compounds, yet abundant in sludge, to which reactives with a basis of Fe and Al, used either for chemical removal of phosphorus from sludge or for chemical conditioning of sludge, are added.

High Fe and Al values, together with sludge which is rich in lime, around pH = 10, act negatively on the ground being available sequestering agents of phosphorus.

For presence of these additives, even if neither particularly toxic nor particularly noxious to the ground, the preference for agricultural use should be oriented towards stabilized liquid sludge.

The treatment of sludge, besides the chemical compound, reducing humidity, influences on the physical consistency of the very same and thus conditions the various lifting systems, the transport and the distribution over the ground.

Also for this reason, as evidenced in Table 3, the kind of sludge most frequently dumped on agricultural grounds is the digested liquid.

In conclusion, the supply of fertilizing and conditioning substances, even if not comparable to that of a mineral fertilizer, is placed on almost the same level as manure (Tab. 4).

Table 3 Typical composition of treated waste water sludge and of manure (% dry)

Compounds	*Sludge*	*Manure*
Carbon	33,5	36,2
Nitrogen	3,9	2,2
Phosphorus (P_2O_5)	5,7	1,3
Calcium	4,9	2,6
Magnesium	0,6	0,3

Table 4 Transport systems and distribution in function of the sludge's humidity

Humidity (% water)	*Physical consistence*	*Lifting systems*	*Transport by*	*Distribution system*
100	liquid [a)]	centrifugal pumps with backward impeller and cutter	railroad tank car or tank car	- spreading by aspersion - infiltration from grooves - injection into the subsoil
90	pasty [b)] (little adapted to distribution)	volumetric pumps (mono)	open container type garbage truck or tipping lorry	injection systems
70	semisolid [c)] (shovellable)	mechanic or manual shovelling	tipping lorry or towed carts	by manure spreader
20	solid friable [d)] (granular or pulverulent)	mechanical or manual shovelling, pneumatic transport	tipping lorry or towed carts	by manure spreader

Dehydration systems:
a) thickening + aerobic digestion
b) thickening + aerobic digestion + chemical or thermal conditioning + centrifuging
c) thickening + aerobic digestion + (natural drying) chemical or thermal conditioning + filter press, belt press or vacuum filter
d) thickening + centrifuging + thermal thickening

Nitrogen
It is an indispensable element to vegetative processes, as it affects the development of leafage and thus it conditions the development of vegetables and their production; if the quantity should be excessive it might produce retardatory maturation, products too rich in water and reduce its resistance to parasites.
About 70% of total nitrogen is present in sludge in organic form, while the remaining is under ammonia form. Considering that normally more then 10% ammonia volatilizes (in sludge treated with lime even more) and that the organic fraction must be mineralized, we can estimate that only 20-50% of the totally on the ground discharged nitrogen will be available, while the remaining petrifies at a rate of 15% a year. Moreover, we must bear in mind that the absorbable nitrogen forms with radical hair are those soluble NH_4 and NO_3^{-1}.
As during digestion the organic nitrogen transforms in ammonia, present in soluble form, derives that the digested sludge and especially that dehydrated digested, has a nitrogen content inferior to that of fresh sludge. In liquid digested sludge, soluble ammonia is absorbable by vegetables, almost as that supplied by chemical fertilizers.

Phosphorus
Is necessary to processing of lymph, it influences development of the radical apparatus, favours maturation, stimulates vegetative processes and improves resistance against illness. It is present in sludge prevalently in inorganic form and its efficacy is about half of that of superphosphate, but unlike nitrogen, it is not dispersed by solubilization and percolation.
Mineral phosphorus is most of all present in iron, aluminium, lime and magnesium compounds, which abound in most sludge.

This tenor of phosphorus, which is higher than that of dung makes dumping to become interesting. One thinks that almost half of the discharged phosphorus becomes available the year successive to application.

Potassium
Even this is essential to the processing of lymph, influences the growth of the trunk and of the eventual woody parts, on the dimension of the fruits and its deficiency reduces sugar and starch forming (for example in sugar beets and potatoes).
Unlike N and P, which in normal dosage of sludge are well balanced and sufficient, potassium is usually poor and thus the supply of sludge as fertilizer should be integrated with potassium coming from other sources.

Calcium
It is essential to the vegetable structure, favours transfer of sugars and starch and reduces the sensibility to toxic substances. Besides being used as corrective of acidity of the ground, modifies its structure (especially for argillaceous grounds) facilitating its fragmentation and it acts even on CEC (cation exchange capacity).
The dehydrated sludge naturally contains up to 5% CaO in dry, while the artificially dehydrated sludge, previous chemical conditioning, contains up to 25% of it in dry.
As it is dispersed by percolation, calcium is integrated using $Ca(OH)_2$, especially in ground strongly treated with nitrate chemical fertilizers. But we should bear in mind that an excess of lime involves difficulty of phosphorus and micro-nutrients assimilation.

Micro-nutrients
Microelements (B, Fe, Mn, Cu, Zn, Se, Mo, Co), in low concentration, are considered essential for the growth of vegetables; other elements (As, Cd, Pb, Mg, Ni, Cr) seem not to be as many. Their absorption from vegetables depends on many factors, among which pH, CEC, organic substances content, kind of cultivation.
It is to be considered that some micro-nutrients, besides being essential for vegetables, the same is also (or only) worth for animals and a good deal of it are having characteristics of toxicity for the ones and/or for the others, in elevate concentrations; in Table 5 these characteristics have been reassumed.

Table 5 Essentiality and toxicity of some oligoelements for vegetables and animals

Element	*Essentiality*		*Toxicity*	
	vegetables	*animals*	*vegetables(*)*	*animals*
Cd	no	no	M	H(**)
Cr	no	no	L	L(**)
Cu	yes	yes	H	M
Pb	no	no	L	H(**)
Ha	no	no	L	H(**)
Ni	no	yes	H	M
Zn	yes	yes	M	L

M = moderate, L = low, H = high
(*) When the metal is given on the soil
(**) Cumulative effects

LIMITATIONS TO AGRICULTURAL USE OF SLUDGE

In the light of the stated problems it is good to list which are the limits being the ground of the unavoidable binding prohibitions in terms of rules or prescriptions:

- substances which damage the soil;
- substances which damage the cultures;
- substances which damage human and animals;
- infective disease diffusion risk;
- smell;
- contamination of well water destined to caption;
- contamination of ground water;
- erosion, occlusion and anaerobiosis of the soil;
- hygiene to the operators;
- hygienic storage.

11) DICTIONARY OF TECHNICAL TERMS USED IN THE WASTE WATER TREATMENT SECTOR

Acceptability norms, complex of chemical-physical or biochemical standards, imposed by law to any effluent destined to be discharged in public water, either superficial or under ground. The definition to adapt acceptability norms constitutes the only valid mean to fight pollution of natural water.

Acids and basics, chemical substances which act respectively as donors and acceptors of protons. More simply, are called *acids* the aqueous solutions in which predominate hydrogen ions, *basic* or *alkaline* those in which predominate hydroxyl ions, *neutral* those with equal contents of both types of ions.

Activated carbon, substance endowed with a remarkable absorbening power of vegetal or mineral origin. When exhausted, it regenerates by means of water or steam backwashing, or by thermic reactivation.

Activated sludge, *aerobio* purifying method of polluted water based on the fact that, when a liquid is submitted to *aeration*, sludge, made up by colonies of aerobic micro-organisms which feed on organic substances held in the very liquid, purifying it (*biologic oxidation*), forms.

Adsorption, tendency of a substance in solution (in liquid or gaseous state), to adhere to the surfaces of a solid substance, in relation to the revealed tendency of diminishing of the free energy of the said surface. As a consequence, the best adsorbent materials are those porous (*activated carbon*). The adsorption increases at rising of the pressure and at decreasing of temperature; it is the more stronger as the molecular weight of the absorbed substance is the less higher.

Aeration, introduction of air in an aqueous solution, with the goal to restore the saturation in dissolved oxygen in it. *Henry's Law* regulates the solubility of oxygen in water to the balance, which is achieved as sooner as the turbulence of water is greater.

Aerobio, organisms which can live only in presence of free oxygen.

Alkalinity, characteristic property of *basics*, contrary to *acidity*, which is typical of *acids*. Natural water is alkaline when its *pH* is

higher than 7 ("actual alkalinity"); its "stechiometric alkalinity " instead is given from the total bicarbonate ion content, carbonate and hydrate, measured by methyl orange titration with a titrated acid solution. It is expressed in ppm of $CaCO_3$.

Algae, inferior undifferentiated plants, prevalently aquatic, cryptogamic tallophites. They content chlorophyll and various coloured pigments, which make them suitable to the environment conditions of light.

Ammonia, acrid smelling gas, formula NH_3, very soluble in water to which imparts an alkaline reaction:

$$\rightleftharpoons \quad NH_3 + H_2O \quad NH_4^+ + OH^-$$

Ammonia is the final product of anaerobic decomposition of organic nitrate substances; in non ionised form it is greatly toxic for the ichthyofauna.

Anaerobic digestion, biological treatment of very concentrated organic sewage, carried out in closed vessels (digesters) and due to the anaerobic *bacteria*. The d. produces remarkable quantities of *carbonic anhydride and methane* which is used to heat the digesters to 25-38 °C.

Anaerobio, organism which can or must live in absence of free oxygen, and thus it exports the oxygen from oxygenated compounds, reducing them.

Automation, technique having the goal to make a technological process totally o partially independent from men's intervention, in which the same series of operations are repeated in the course of time, with or without variants. Automation presumes a continuous control of the process and the capacity of direct intervention, or at least emission of an alarm signal, in case the process runs out of the established scheme. Automatic proceedings are particularly useful for chemical-physical treatment control.

Bacteria, micro-organisms belonging, as algae, to the vegetable kingdom, but deprived of chlorophyll. The pathogenic bacterias (agents of disease) must be eliminated from water for alimentary use (*chlorination, disinfection, ozonation, potabilization*). Among non pathogen bacteria there are: nitrifying b., which transform ammonia into nitrite and nitrate, denitrifying b., which reduce it in elementary nitrogen; sulphur reducing and sulphur oxydizing b., which transform sulphured compounds respectively in hydrogen sulphide and in sulphuric acid; ferric b., which transform the compounds of dissolved iron in ferric hydroxide. Bacteria can be *aerobic* or *anaerobic*.

Bactericides, substances which inhibit the vital activities of bacteria, through interference in the osmosis balance or in their enzymatic system. Sometimes, after a period of acclimatisation, bacteria are able to tolerate toxic bacteriostatic doses, some other time they succumb, with great damage for the biologic treatment processes.

Bacteriologic analysis, identification and calculation of bacteria of various specimen, present in a certain water volume, which's result is expressed as "most probable number" (MPN). It is carried out to establish the *drinkability of* water and to control the functioning of biological waste water treatment plants.

Biochemical oxygen demand or **BOD**, quantity of oxygen required for the *aerobia* decomposition of the organic substances contained in water for 5 days at 20°C; it is expressed in ppm of oxygen. BOD is one of the most usual systems which gives the measure of the organic pollution grade of water, however, its determination is subject to various causes of mistake, which reduces its reliability.

Biodegradability, property, which are having most of the organic substances and many of the inorganic ones, consisting in being attacked and destroyed completely by micro-organisms living in natural water and in biological waste water plants.

Biological denitrification, process based on action of facultative aerobe *bacterias* which reduce oxidised compounds of nitrogen to elementary nitrogen, which frees itself in gaseous form. It is used in treatment of sewage bounded to still waters (lakes, coastal water), to avoid nutriment saturation (eutrofization?)

Biological deposits, organic deposit, made up by colonies of micro-organisms, which form often in industrial water conduits and in heat exchangers, clogging them, reducing the thermic transmission and provoking corrosion. They are fought by *disinfection*.

Biological filtration, *aerobio* purifying method, consisting in sludge spreading on a bed consisting in a filtering mean of suitable size (gravel, coke, plastic, etc.). The sludge percolates through the mean, finding air which rises by natural or forced draught, and this favours forming, on the surfaces of these means, of a gelatinous film of aerobio micro-organisms, which cause the transformation of the organic substances.

Biological oxidation, treatment consisting in satisfying BOD, or the *biochemical oxygen demand*, of the polluted water (*activated sludge*, *biological filtration*, *oxidation pits*), in such a way that the biological processes of demolishing of the organic substances evolve in aerobic sense, forming final products relatively innocuous, such as: carbon dioxide, nitrate, sulphate, phosphate.

Carbon dioxide, odourless gas, formula CO_2, heavier than air, moderately soluble in water, forming carbonic acid H_2CO_3. It is produced by combustion of carbon and his organic compounds, in case of oxygen excess.

Chemical coagulation, thickening of the particles of a colloidal dispersion in flocs of major dimensions, which thus can sediment (*sedimentation*). It is obtained by addition of bi- or trivalent metal salts (calcium, magnesium, zinc, iron, aluminium) which's cations attenuate the electrostatic power of repulsion between the particles; the latter combine in flocs thanks to the powers of *Van der Waals*. Plays also the fact that the hydroxides of bi- and trivalent metals have a low product of *solubility* and they precipitate in flocs, which drag the suspended particles with them by action, in part mechanical, in part electrostatic. The c. depends mainly on: pH, temperature, reaction time, reagent doses, agitation speed. Normally it is followed by *sedimentation, filtration* or *floatation*.
Main coagulant reagents: aluminium sulphate (pH 5-7), ferrous chlorine (pH 4-10), ferrous sulphate (pH 8-11). Substances as activated silica, polyelectrolyte and bentonite are said *coagulation auxiliaries* which, added to coagulants, improve the results of the coagulation process.

Chemical oxygen demand or **COD**, quantity of oxygen, expressed in ppm, needed for oxidation of oxidable substances contained in water, carried out by reflux through a solution of potassium bichromate in sulphuric acid. It is perfectly reproducible and thus it supplies a reliable measure of pollution, even if conventional.

Chemical-physical analysis, quantitative identification and determination, carried out by means of reagents and equipment, of desirable or undesirable substances, contained in a representative water sample on approval. It has the worth of exactness and of reproducibility, and the defect of validity, limited to the moment and the place of the taking of the sample. Partially this inconvenience can be remedied by continuous automatical analysis.

Chlorination, introduction of chlorine or its compounds in water, as chemical oxidant or for *disinfection*. The bactericide power of chlorine, probably due to the formation of nascent oxygen, depends mainly on the pH, on the temperature and on the chlorine concentration.

Chlorine demand, difference between chlorine introduced in water and residual chlorine noticed after a certain reaction time. A tenor of residual chlorine of 0,5-1 ppm after 10 minutes is normally sufficient for water for alimentary use.

Colloids, substances which's particles remain suspended in the water as per their smallness (1-200 mμ).
They have movements called "brownies" due to bombardment of the solvent molecules. They are too big to pass the pores of half permeable membranes, unlike real solutes, from which they thus separate by *dialysis*

Compensation or **balancing**, mixing and homogenisation of different sewage, usually coming from different working phases of a factory, with the goal to avoid the inlet of unforeseen effluents, containing strong quantities of certain polluting substances into the treatment plant, which performance should be compromised. The most common retention time is one working day.

Corrosion, alienation or deterioration of material under chemical or electrochemical action of the surrounding mean. The c. of metal in aqueous solutions is an electrochemical phenomenon. On the exposed surface form anodic zones where metal melts and catodic zones where hydrogen (acid solutions)develop or hyxodryl ions form (Neutral or alkaline sol.).
The presence of carbonic anhydride, rendering the mean more acid, quicken the development of hydrogen, while presence of dissolved oxygen has a *depolarizing* effect, which means, it removes the obstacles which come between the development of the corrosive phenomena; that's why both of these gasses (CO_2 e O_2) are fearful stimulators of corrosion.

Demineralization, removal of mineral substances dissolved in water; for total d. *ion exchange* is used.

Desanding, separation of siliceous rubbish with diameter greater than 0,2 mm from sewage, by means of passage with controlled velocity through apposite channels where they settle.

Disinfection, elimination of micro-organisms, particularly of those pathogen. They are generally effected by *chloration* or *ozonization*, on water destined to civil use, on water of industrial use and on effluents of various origin.

Disoiling and degreasing, removal of oily or greasy substances from sewage by simple overflow or through *absorption, coagulation, floatation, biological oxidation*.

Disposal fee, tribute to which must be submitted the agricultural and industrial undertakings which reverse their proper residual water, raw or partially purified, into the urban sewer. It is calculated determining the *equivalent of inhabitants,* or rather the *tractability* of the above residual water.

Dyes, natural substances, synthetic or from mineral origin, which produces a showy but not always serious pollution, in water. Generally they are removed by *absorption or coagulation.*

Electrolytic conductivity, property of fused salts and of aqueous solutions of electrolytes (acids, bases, salts) to conduct the electric current with ion migration, on the contrary of electronic *conductivity,* typical of metals, in which the flow of electrons occurs without transport of matter.
The c. is important as a measure of the global quantity of ionised substances present in water.

Enzymes, specific biologic catalysts made up by nitrated substances produced directly by the *cells*. Each enzyme affects a substance, or a well individuated group of substances, called substratum. The e. have a great importance in the biological waste water treatment process.

Eutrofization, natural evolutive phenomenon of lakes, consisting in progressive decrease, in the course of time, of oxygen content from the deep strata of water (*ipolimnio*). The e. is a consequence of increase of organic substance, produced by the biological living population in the lake, owing to accumulation of *nutritive substances* in lake water. The e. which is very slow in nature, is strongly accelerated by discharge of all kinds; the only remedy consists in removal of the nutrient substances, or at least of the phosphoric compounds, from all waters destined to immission in lacustrine surroundings.

Fermentation, this name is given to particular biochemical reactions, operated by micro-organisms which secrete *enzymes*, producing well defined chemical substances.

Filter pressing, discontinuous dehydration process of half-liquid sludge by means of a filter press, consisting in a series of blades and frames, arranged alternatively on a bearing guide. The sludge is pumped at a pressure of 4-87 atm in the filter press, and the liquid comes out of it; after 4-12 hours the equipment opens and the sludge panels are extracted holding 25-45% of humidity.

Floatation, separation of suspended solid substances, or substances in emulsion, from a liquid, thanks to either their low specific weight, or by injection of a gaseous current, which induce them to float. Floatation is particularly adapted to fat and oily substance removal.

Flocculation, term normally used as synonymous of *chemical coagulation*, actually it is only a phase of coagulation, during which the single particles thicken and form flocs of major dimensions, which settle faster. Flocculation is favoured by agitation of the liquid, such to encourage the encounter of the single particles, but not excessive, for not breaking the flocs already formed.

Flos aquae, improvise flowering of enormous quantity of algae which occur in certain seasons in lakes or sea bays. Generally they are in correlation with an excessive patrimonial of organic substances.

Foam, forming of a more or less stable layer of bubbles of a gas on the surface of a liquid, covered by a liquid pellicle. The stability of the s. is correlated with the *superficial tension* of the liquid.

Fungus, vegetal micro-organisms which, unlike *algae*, are not able to synthesize the to them occurring nourishment. They depend thus on the disposability of the nourishing substances of the environment, but in return they can also develop in absence of sun light.

Hardness, contents of water in calcium and magnesium ions, which is determined by titration with EDTA and expressed in mg/lt, ppm $CaCo_3$ o °F.

Hydrocarbides, organic substances consisting in carbon and hydrogen. The principle h. gaseous is *methane* while petroleum and its derivatives are mixtures of liquid h.

Imhoff tanks, also called *septic tanks*, serve for o anaerobic treatment of sewerage water coming from isolated residences, devoid of connection to the municipal sewer. They are sometimes used, in combination with *biological filtration* for treatment of sludge of small towns up to 10.000 inhabitants.

Inhabitants equivalent, number of inhabitants whose waste, discharged in a day, should adsorb a quantity of oxygen, measured on base of BOD, equal to that adsorbed from the daily discharges of a given industry. It is a parameter adopted to compare, approximately, the polluting power of an industrial effluent to those of a "standard" cloacal sewage, supposing that the daily oxygen consumption will be 54 g oxygen per inhabitant.

Inverse osmosis, treatment consisting in applying external pressure, higher than the *osmotic pressure*, in a cell with two compartment containing respectively pure water and a concentrate solution, and separated by an osmotic membrane. The normal osmotic process is inverted and the water passes from the second compartment to the first one, leaving the solutes behind.

Ion exchange, property of certain natural silicates (zeolites) and of various synthetic resins, consisting in ceding to electrolyte solutions, with which they come into contact, determined ions, assuming in change other ions which are content in the aforesaid solutions. Ion exchange serves in a particular way to softening or *demineralization* of water, as well as to purifying of particular residual industrial water.

Mechanical filtration, passage of a suspension through a bed of particles of suited nature and dimensions, in a way that the suspended substances are kept by the bed and on the contrary the fluid can proceed beyond; the force which provokes filtration may be natural gravity or a gradient of pressure. In the "immedium" filters the drainage system is immersed in the filtering layer.
Very important is periodical washing, which in gravity and pressure filters is carried out in counter current and in those vacuum by means of water jets on the cloth.

Metabolism, a whole of biochemical processes which occur in a living organism, and of the matching energetic manifestations. The term m. is synonymous of *exchange*, in the sense of continuous exchange of the living substances. They are distinguished in two phases, anyway always concomitant: *anabolism*, during which new cells synthesize, and *catabolism*, in which the substances which make up the tissue are degraded to always simpler compounds, which are eliminated at the end through the excreting organs.

Micro-organisms, mono-cellular living beings, visible only with help of the microscope (*algae*, *bacteria*, *fungus, protozoa*).

Mineralization, transformation which organic substances undergo, till production of final inorganic substances, or minerals.

Neutralization, treatment of an acid solution with an alkaline reagent, with the goal to increment the pH, or of a alkaline solution with an e acid reagent, with the goal to decrease it.

Nitrification, transformation of ammonia in nitrite, operated by the nitrose-bacteria (*Nitrosomonas*), or in nitrate, by the work of the nitrobacteria (*Nitrobacter*). It constitutes a very important phase of the *biological oxidation*.

Nitrogen, gaseous element, symbol N, N_2 bi-atomic molecule, endowed with a great chemical inertia. It is found in the atmosphere, of which it forms about 4/5 in volume, in organic substances and as nitrite o nitrate, in rural ground, where it forms, as phosphorus, one of the fundamental fertilising principals.

Oxidation pit, *aerobe* method of purifying based on use of one or more pits which consists in two parallel united channels at the opposite extremity of semicircular connections. The sludge enters the pit and passes the ring more times, pushed and simultaneously aerated by a mechanical system (rotating brushes) or by a compressed air flow. The produced sludge is completely mineralized and thus not putrescible.

Oxide-reduction, chemical reaction in which a donor (oxidizing) cedes one or more electrons to an acceptor (reducing). In practice after, it is said oxidation, or reduction, depending on whether interests more the one or the other aspect of the phenomenon. Also *biological oxidation* is an oxide-reduction, but in the residual water treatment sector it is preferred to reserve this name to use of oxidizing reagents (hydrogen peroxide, chlorine, hypochlorite, ozone) or of reducers (sulphurous acid, disulphite, iron sulphate).

Polyelectrolyte, linear hydrosoluble organic polymers, with ionic groups distributed along their filiform molecule. They are used, in minimum dosage, as auxiliary in *coagulation*, to improve the performance of the reagents, or even alone, as coagulants.

Precipitation, separation in solid state of a substance which was dissolved in a solvent. If the substance is an electrolyte, its precipitation is regulated by the product of solubility (*solubility*).

Protozoa, unicellular animal micro-organisms, with rudimental locomotion organs, called ciliates, flagellates and pseudopodes. The p. are having an important part in *biological oxidation*.

Radioactivity, spontaneous disintegration of the nucleus of some elements.

Retention time, meters the duration of permanence of sludge in a determined phase of the di purification process. Its entity is very important, either to the treatment's efficacy effects, or to those economical.

Screening, removal of coarse solid substances from sludge, by means of passage through fix or mobile screens.

Sedimentation, operation by means of which the suspended solid substances in a liquid have got to settle on the bottom of a suitable tank, thanks to its force of gravity.

Sediments, deposit of organic or mineral insoluble substances, which form on the bottom of natural water bodies.

Selfcleaning power, capacity of natural water to digest a polluting load imposed to it, thanks to the work of the aerobic micro-organisms, which demolish the organic substances forming relatively innocuous final products.

Solubility, property of a substance to form with another substance a physical mixture (i.e. a miscellaneous which's compounds can be separated by bland physical means, such as distillation or freezing). The solubility of a substance is limited by its *saturation* value in the given solvent, exceeding which the substance does not melt any more or, if already melted to excess, precipitates.

Spray irrigation, method of dumping of certain residual agricultural or industrial water, which could be absorbed by the ground without sensible harm, and on the contrary, sometimes they could bring benefit to the cultures. It is applicable especially in countries having vast surfaces of non built ground

Sulphorated hydrogen, or sulphydric acid, gas with smell of rotten eggs. It is the last product of anaerobic decomposition of sulphorated organic substances; it is strongly toxic for the ichtyofauna, especially in the non ionized form.

Superficial tension, property determined by the molecular forces of the superficial pellicle of the liquids, which tend to assume to the very same liquid the form which assures the minimum surface for a given volume.
Foam forming increases remarkably the surface of a liquid; that's why addition of substances which diminish the superficial tension (*synthetic detergents*) makes foaming easier.

Suspension, mechanical mixture (i.e. a miscellaneous which's compound can be separated by mechanical means) of solid particles dispersed uniformly in a liquid.

Synthetical detergents, organic substances generally surfactants which, unlike soap, clean well even in hard water and they have more bathing, dispersing and emulsifying properties. They distinguish in anionic (alkylbenzensulphonates or ABS) non-ionic and cationic; the first ones (ABS) are the most used. They are noxious for their tendency of *foam* forming, and because they disturb *aeration* and *sedimentation*. The ABS are not biodegradable because of ramification of their molecular chain, so they are prohibited by the legislation of various countries; at their place LAS at linear chain, biodegradable are used.

Tampon power, capacity of self-regulating of the *pH* in solutions of week acid and its salt, or of a week base and its salt. Moderate addition of a strong acid, or of a strong base, keeps the pH practically unchanged, when the tampon power of the solution is remarkable.

FORMULAS

CALCULATION FORMULAS OF THE PRINCIPLE PARAMETERS OF THE PROCESS

Equivalent inhabitants 60 g BOD_5/d

Equivalent inhabitants 118 g COD/d

Hydraulic retention time (HRT)

$$\frac{\text{Volume oxidation tank (m}^3\text{)}}{\text{Average daily flow (m}^3\text{/day)}} * 24 = \text{(h)}$$

Sludge load (F/M)

$$\frac{(\text{BOD}_5 \text{ IN (mg/l)} * \text{Average influent to the biological (m}^3\text{/d))/1000}}{(\text{Volume oxidation tank (m}^3\text{)} * \text{MLVSS (g/l))}} = \left(\frac{\text{Kg BOD}_5}{\text{Kg MLVSS}} * d^{-1}\right)$$

Sludge age (SRT, θ)

$$\frac{\text{Q sludge surplus (m}^3\text{/d)} * \text{SS recycling (g/l)}}{\text{volume oxidation tank (m}^3\text{)} * \text{SS ox (g/l)}} = (d^{-1})$$

SVI (Mohlman index)

$$\frac{\text{settling sludge 30' (ml/l)}}{\text{MLSS (g/l)}} = \text{(ml/g)}$$

DSVI (diluted sludge volume index) (ml/g)

$$\frac{\text{settling sludge 30' (ml/l)} * \text{dilution factor}}{\text{MLSS (g/l)}} =$$

Efficiency %

$$\frac{\text{Conc. parameter IN} - \text{Conc. Parameter OUT}}{\text{Conc. Parameter IN}} * 100$$

Sedimentation tank speed

$$\frac{\text{Flow m3/h}}{\text{Sedimentation area}} = \text{(mt/h)}$$

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