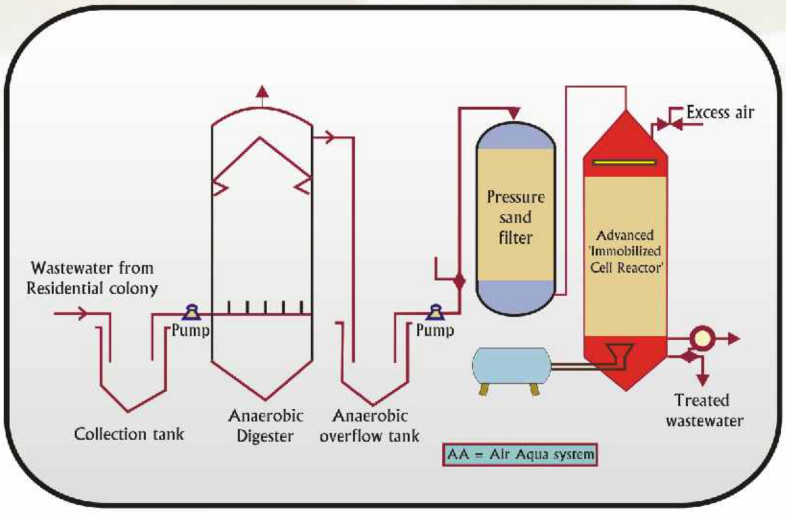
Sewage Treatment Plants

Using The Latest

Advanced Immobilized Cell Reactor Technology



Your Sewage treatment plants can now:

- be up to 50% more efficient,
- occupy 50% less space,
- require 50% fewer maintenance staff,
- have odor completely removed,
- cost up to 50% less.

For Commercial Inquiries (Plant Purchase, Installation, Commissioning & Maintenance, OR for Technology Licensing), Please [Contact me here]

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Professional Help/ Advice on Sewage Treatment, and related topics

This eBooklet, commissioned by Geostar Publishing LLC, is part of a larger eBook titled, "All About Wastewater Treatment", which is a compilation of material written by several authors who are specialists in their respective realms of Sewage Treatment.

If you need professional advice/ consultancy from the authors or the organizations they represent, we will put you in touch with the respective authors. This service is offered on a 'FREE of cost', 'non-obligatory' basis. Email us at support@All-About-WasteWater-Treatment.com, with details of your specific requirement. Or visit:

http://www.All-About-WasteWater-Treatment.com/helpdesk and post your requirement, with details, as a Ticket. We'll forward your requirements to the respective author, and get his/ her to reply within a week, normally much sooner.

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Commercial Aspects Of This Technology

This new technology in Sewage Treatment, called Advanced Immobilized Cell Reactor technology, promises benefits like:

- ♦ Up to 25% lower plant cost
- ♦ Up to 50% lower operating costs
- ♦ Up to 50% lower maintenance costs
- ♦ Up to 90% less sludge production
- ♦ Up to 60% smaller footprint (can even be set up underground or on the roof)

Speedy plant construction (2 to 6 weeks for small/medium sized plants)

Insures high purity level of treated water, as below:

(i) BOD (Biological Oxygen Demand): less than 5 mg/Liter,

(ii) COD (Chemical Oxygen Demand): less than 60 mg/Liter (or even better)

- ♦ Meets EVA specifications of the US and UK

- Meets all input specifications of wastewater from large industries/ cities/ towns.
- Has a very high potential to get Carbon Credits (though not yet attempted).
- This technology has varied applications:
- Small sizes for both industrial and domestic applications.
- Can also be made in standard sized, skid-mounted form
- Can be readily installed cost effectively in small homes, individual/ small business establishments like car washes, bakeries, restaurants, mini-hotels, etc., and plants for rural areas.
- Can also be installed with Sludge-handling model or Sludge-absorption model for Domestic use
- Can be used to facilitate re-use of water for purposes like golf courses, toilets, gardening, and even washing.
- Or just let off the treated water to recharge the ground water.

Additional Merits of This Technology:

- Less Land Requirement
- Less Electrical And Mechanical Equipments
- Less Detention Period (1 - 4 Hrs.)
- Less Power Consumption (About 30% Of The Conventional)
- Aeration Tank Is Not Required
- No Foaming Problem
- No Addition Of Micro /Macro Nutrients
- No Biomass Production
- No Secondary Settling
- Tertiary Treatment Is Not Required
- Positive Response To Achieve Discharging Standards (BOD < 30 mg/L, COD < 250mg/L)
- Complete Removal Of Colour And Odour
- Possibilities To Reuse The Treated Effluent

- Scalability: Provision To Handle Additional Load By Adding More Number Of Modules
- Need Not Work On Holidays
- Supports The Growth Of Vegetative Plants. Treated Effluent Can Be Used For Agricultural/ Recreational Purposes
- Pay Back Period Of this System Is Low Due To Saving On Electrical Power & Chemical Consumption

What's more, it is cost effective to implement small Plants using this technology anywhere in the world, with mostly indigenous material and conforming to local standards. This technology has been implemented successfully in many locations.

The Advanced 'Immobilized Cell Reactor' technology can also be applied to the treatment of domestic wastewater. The presence of organic, inorganic chemicals, and organisms, both pathogenic and non-pathogenic in nature, make domestic wastewater complex. Conventional biological treatment systems do not remove dissolved organics and microorganisms satisfactorily.

Moreover, the systems are not efficient enough to recover the water for reuse purpose. Integrated biological and chemical oxidation happens in a single reactor. The reactor consists of a tall column packed with activated carbon. The activated carbon is immobilized with chemo autotrophs. Oxygen required for the oxidation of organics in wastewater is supplied in the form of compressed air from the bottom of the reactor. The counter-current movement of the liquid and air streams enables the dissolved organics to undergo oxidation and desorb the converted products, so that the activated carbon maintains its activity throughout the operation. The domestic wastewater treated through Advanced 'Immobilized Cell Reactor' system has reduced BOD by 94%, COD by 90% and sulfide by 100%.

- However, this technology also has some limitations:
- Permeability index is less than that of sand filters
- Maximum organic loading rate allowed is limited
- Performance is limited by the presence of suspended solids in wastewater.

- Anaerobic treatment is an essential unit of operation before proceeding to Advanced 'Immobilized Cell Reactor' reactor to reduce the viscosity of wastewater and eliminate colloidal solids.

- Multiple modules are required to handle huge volumes instead of a single module.

All in all, the Advanced 'Immobilized Cell Reactor' technology can be applied across a wide spectrum of industries. It has performed at a credible level for the removal of organics estimated as BOD and COD from wastewater generated in leather garment manufacturing, textile-yarn-dyeing , sago, chemical, and pharmaceutical industries.

Technical Aspects Of This Technology

1 Immobilized cell reactor

Amongst the technologies, immobilized cell oxidation process has been used more successfully for the treatment of wastewater. Immobilized cells have been defined as cells that are entrapped within or associated with an insoluble matrix. Mattiasson discussed six general method of immobilization: covalent coupling, adsorption, biospecific affinity, entrapment in a three dimensional polymer network, confinement in a liquid-liquid emulsion, and entrapment within a semi permeable membrane.

Under many conditions, immobilized cells have an advantage over either free cells or immobilized enzymes. By preventing washout, immobilization allows a high cell density to be maintained in a bio-reactor at any flow rate. Catalytic stability is greater for immobilized cells and some immobilized microorganisms tolerate higher concentration of toxic compounds than do their non-immobilized counterparts.

One partial disadvantage of immobilization is the increased resistance of substrates and products to diffusion through matrices used for immobilization. Owing to the low solubility of oxygen in water and the high local cell density, oxygen transfer often becomes the rate limiting factor in the performance of aerobic immobilized cell systems. Thus when aerobic cells are used, aeration technique bears a very important consideration in bioreactor design technology.

Advanced 'Immobilized Cell Reactor' employing aerobic cells, has been recommended for the treatment of even tannery wastewater. This technology comprises of immobilization of chemo-autotrophs, oxidation of dissolved organics in water and filtration of treated water. The activated carbon serves as a matrix to facilitate selective solute transfer, enhanced bio film attachment or restricts the permeation of microorganisms to the downstream.

2 Advanced 'Immobilized Cell Reactor' technology for treatment of wastewater

The concepts deployed in this technology are:

1. Immobilisation of organisms in the carrier matrix will prevent the dissipation of oxygen

2. Accessibility of enzymes to the substrate is increased by reducing the mean free path of the bio catalyst to the substrate

3. Reduce the cellular synthesis by using the organisms with low-yield coefficient

In Advanced 'Immobilized Cell Reactor' technology, the carrier matrix used is activated carbon of low surface area. The characteristics of carbon is presented in table 1.

The bacteria immobilized in anoxic zone can fragment the organics into simpler compounds and the bacteria in oxic zone perform oxidation of organics. In addition to bacterial oxidation, catalytic oxidation is also facilitated at the active sites of the carbon matrix. The heat of combustion of organics released at the active sites will be used for excitation of organic molecules to cross over the activation energy barrier, which normally determines the rate of any chemical reaction.

The freedom of movement of molecules is also restricted at the surface of adsorbent as they are anchored at the sites. Thus energy expenditure towards translational motion, which is considered to be the major component in the orientation of molecule, is lowered to maximum extent. The partially oxidized organic molecule is aerobically oxidized with low heat of combustion by aerobic organisms immobilized at the mouth of the pores. Thus, the energy available for cellular synthesis is decreased and consequently the biomass production is decreased. Since the organisms are in immobilized state, the expenditure of energy towards diffusion of organic molecules and oxygen from the bulk liquid to cellular matrix is very minimum compared to that in suspended growth system.

Hence, the conservation of energy in the immobilized state, enhances the rate of degradation of organics in wastewater is much greater than in suspended growth system. The elimination of micropores in the carrier matrix avoids the loss of active sites by irreversible bonding with organic molecules in aqueous environment. Therefore, the number of active sites available for oxidation of organic compounds remains a constant. Thus, the rate of removal of dissolved pollutants in wastewater is nearly constant.

2.1 Advanced 'Immobilized Cell Reactor' technology applied to leather industry

The Advanced 'Immobilized Cell Reactor' system performs at a credible level for the removal of organics estimated as BOD and COD from wastewater generated in garment leather manufacturing industry. The maintenance cost of the effluent treatment plant was reduced, through savings on electricity and chemicals. The treated water supported the growth of vegetative plants and aquatic bred animals.

2.2 Advanced 'Immobilized Cell Reactor' technology applied to textile industry

Advanced 'Immobilized Cell Reactor' system was applied for the treatment of wastewater discharged from textile-yarn-dyeing industry. The wastewater contains the dissolved organics classified under dyestuff, starch, EDTA, citrate etc. The treated wastewater met the discharging standards reused within the industry or used for irrigation purposes.

2.3 Advanced 'Immobilized Cell Reactor' technology applied to sago industry

Tapioca, the commercial crop is a source for production of starch. The potential use of starch is manifold mainly in pharmaceutical, explosives, alcohol fermentation, food industries etc. The industries are engaged in processing of raw tapioca into starch powder through peeling, crushing, washing and settling the milk of starch and drying in solar evaporation pans.

2.4 Advanced 'Immobilized Cell Reactor' technology applied to chemical industry

The industry is engaged in manufacturing certain type of monomers that discharge only 3500 liters per day. The wastewater was of high COD in the range of 70-90 g/l. The treated wastewater was expected to meet the discharging standard of Dubai municipality i.e. COD 3000 mg/l and BOD 1000 mg/l. The suggested treatment technology for the treatment of wastewater was anaerobic treatment followed by Advanced 'Immobilized Cell Reactor' treatment.

The anaerobic system used was anaerobic contact filter filled with polymeric material of void ratio 0.5. The reactor was of height 5.5 m and dia 1.5 m. The anaerobically treated wastewater was treated further in Advanced 'Immobilized Cell Reactor' reactor of height 5 m and dia 1 m. The treated wastewater from Advanced 'Immobilized Cell Reactor' reactor was able to meet the discharging standards prescribed by the regulatory agencies in Dubai.

2.5 Advanced 'Immobilized Cell Reactor' technology applied to pharmaceutical industry

The wastewater discharged is 20 m^3/day and widely varying in its characteristics. Aerobic biological consortia generally used in conventional treatment units are exposed to shock load applications as highly fluctuating organic loads are applied. Hence, aerobic biological system requires a supporting device to offset the shock load application. This system has been proved to be resistant to shock load applications.

The treated wastewater from Advanced 'Immobilized Cell Reactor' based effluent treatment plant could be utilized for irrigation of the crops raised within the premises. Our previous experience on treated wastewater shows that the treated wastewater supports the growth of blue-green algae. This would in turn increase C/N ratio of soil and thus fertility of the soil will be increased.

2.6 Advanced 'Immobilized Cell Reactor' technology applied to treatment of domestic wastewater

Domestic wastewater discharged from domestic sector is complex in nature due to the presence of organic, inorganic chemicals, wide spectrum of organisms that are pathogenic and non-pathogenic in nature. Conventional biological treatment systems fail to accomplish removal of dissolved organics and microorganisms to the satisfactory level. Moreover, the systems are not efficient enough to recover the water for reuse purpose.

Domestic wastewater collected from the staff quarters was screened and passed through a pressure sand filter to remove the suspended solids. The screened domestic wastewater was treated in anaerobic reactor. The anaerobic treated wastewater was applied over the surface of the Advanced 'Immobilized Cell Reactor' reactor. Advanced 'Immobilized Cell Reactor' reactor has an integrated biological and chemical oxidation incorporated in a single reactor. The reactor consists of a tall column (0.6 m height and diameter 0.15 m) packed with activated carbon. The activated carbon is immobilized with chemo autotrophs of capacity 3.5 x 10^7 cells/gm. Oxygen required for the oxidation of organics in wastewater is supplied in the form of compressed air at a pressure 1 - 3 kg/cm^2 from the bottom of the reactor. The counter current movement of the liquid and air streams enables the dissolved organics to undergo oxidation and desorb the converted products, so that the activated carbon maintains its activity throughout the operation. The domestic wastewater treated through Advanced 'Immobilized Cell Reactor' system has removed BOD by 94%, COD by 90% and sulfide by 100%.

- Permeability index is less than that of sand filters
- Maximum organic loading rate allowed is only 1.2 kg COD/m^2 of Advanced 'Immobilized Cell Reactor' reactor.
- Performance of Advanced 'Immobilized Cell Reactor' reactor is limited by the presence of suspended solids in wastewater.
- Anaerobic treatment is an essential unit of operation before proceeding to Advanced 'Immobilized Cell Reactor'

reactor. This is to reduce the viscosity of wastewater and eliminate colloidal solids.

- Multiple modules is required to handle huge volumes instead of a single module.

2.7 Catalysts used in Advanced 'Immobilized Cell Reactor'

Characteristics of catalysts used in Advanced 'Immobilized Cell Reactor' :

Elemental analysis C H N Ash	 48.45 (%) 0.70 (%) 0.10 (%) 50.75 (%)
Bulk density	0.69 (g/m^3)
Specific surface area	218 (m^{2}g)

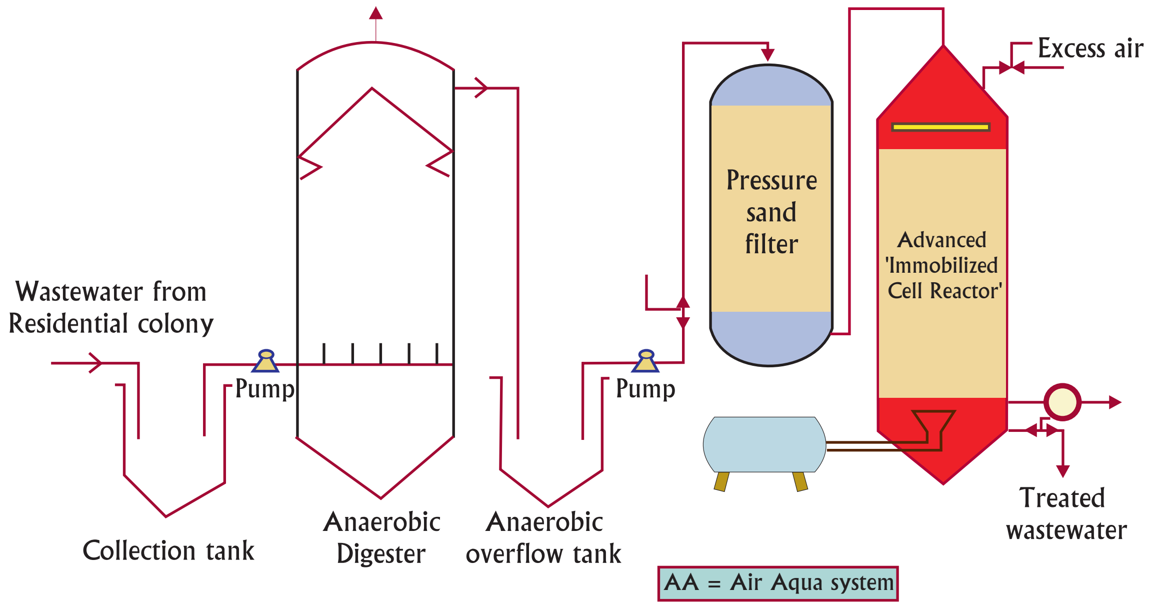


Figure: A General Scheme of A Sewage Treatment Plant using the Advanced 'Immobilized Cell Reactor'

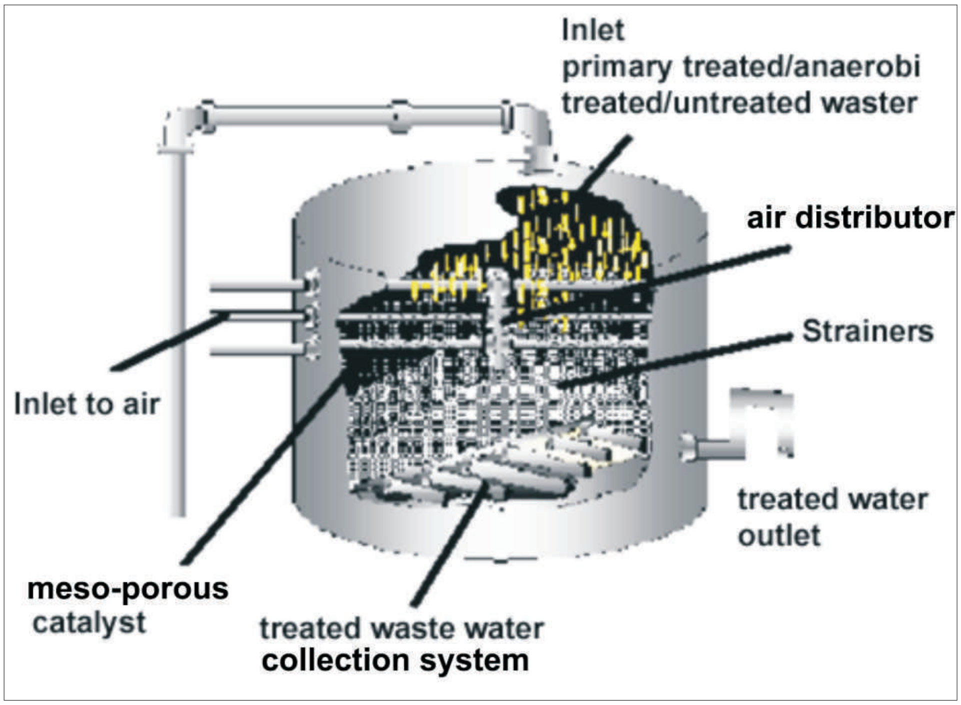


Figure: Inside An Advanced 'Immobilized Cell Reactor'

3. How To Configure The Sewage Treatment Plant Using This Technology For Your Specific Needs

As already discussed, this technology itself is extremely efficient compared to the other technologies in terms of capital cost of building the Plant, cost of operation & maintenance, quantity of sludge generated, odour level, and availability of space. However, three basic models have been developed using this technology, which are even more ideal for the following 3 conditions:

(I) When the sludge generated has to be absolutely the barest minimum (almost zero) or when the cost of maintenance has to be the minimum.

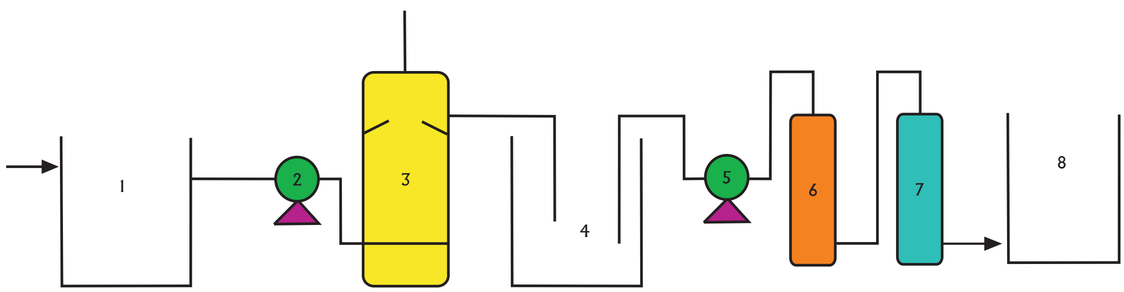
(ii) When the electrical power consumption has to be the lowest, or when the odour tolerance is very low, close to zero.

(iii) When the Capital Investment has to be the lowest, or when the footprint area available for the Plant is small, or when the odour tolerance is very low, close to zero.

Let's see the best schemes suitable for these 3 conditions in the following pages.

3.1 Scheme one: When the sludge generated has to be absolutely the barest minimum (with sludge disposal requirement being only once in 3 years) or when the cost of maintenance has to be the minimum.

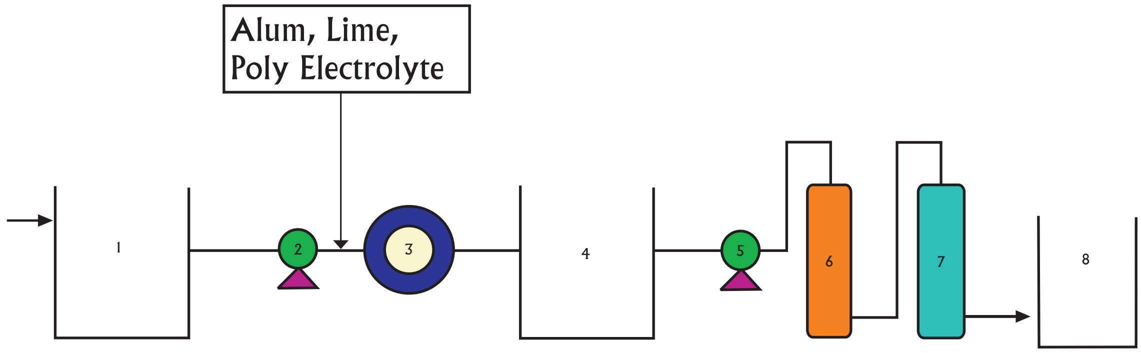
'Anaerobic sand filter'-'Advanced Immobilized Cell Reactor'



1. Collection Tank
2. Raw sewage transfer pump
3. Upflow Hydrolytic Anaerobic Reactor
4. Anaerobic Overflow tank
5. Sand filter pump
6. Sand Filter
7. Advanced Immobilized Cell reactor
8. Treated water collection tank

3.2 Scheme Two : When the electrical power consumption has to be the lowest, or when the odour tolerance is very low, close to zero.

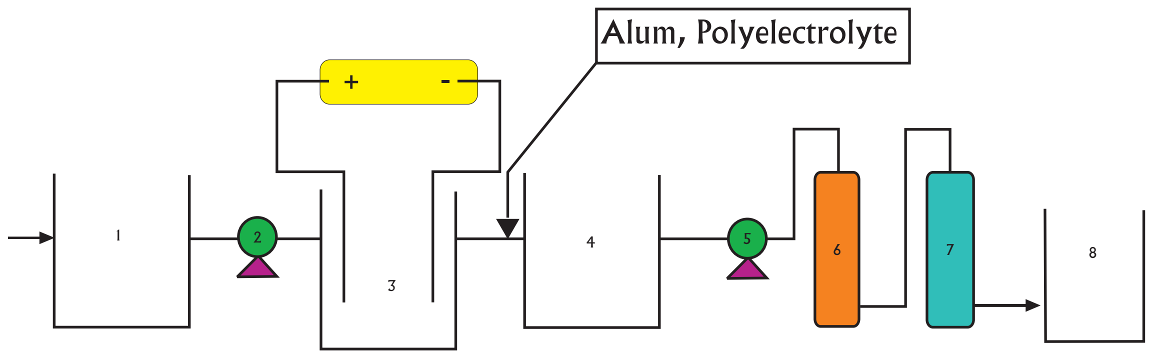
'Primary clarifier'-'Sand filter'-'Advanced Immobilized Cell Reactor'



1. Collection Tank
2. Raw sewage transfer pump
3. Primary clarifier
4. Primary clarifier Overflow tank
5. Sand filter pump
6. Sand Filter
7. Advanced Immobilized Cell reactor
8. Treated water collection tank

3.3 Scheme Three: When the Capital Investment has to be the lowest, or when the footprint area available for the Plant is small, or when the odour tolerance is very low, close to zero.

'Electro-coagulation'-'sand filter'-'Advanced Immobilized Cell Reactor’



1. Collection Tank
2. Raw sewage transfer pump
3. Electro Coagulator
4. Electro coagulator Overflow tank
5. Sand filter pump
6. Sand Filter
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