COST EFFECTIVE EFFLUENT TREATMENT BY SEQUENCING BATCH REACTOR

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Abstract

The overall vision for this research is to optimize a cost and space-effective biological nutrient removal (BNR), Activated Sludge handling system (Granular Activated carbon, Microbial Absorption) to remove nitrogen and other minerals and wastes from effluent for water reuse. The ultimate goal is to protect natural water resources and reduce energy consumption in wastewater treatment. Ammonia/nitrate, heavy metals, BOD, COD, TSS pollution of surface water and groundwater has been a significant problem. The deteriorated natural water resource is the main obstacle for water reuse necessary to save water consumption. Nitrification/denitrification in biological wastewater treatment is the approach commonly used to remove nitrogen from wastewater. However, this process needs large amounts of space, long treatment time, and has a high operational cost, and the performance is not stable. It is critical to develop an innovative cost- and space-effective process in order to solve low nitrogen removal efficiency, and if possible, to provide high effluent quality for water reclamation.

Key words: Effluents, Treatment, Pollution, Wastewater, Industrialization.

1.INTRODUCTION

In view of high cost of conventional wastewater treatment systems, there is an increasing need to develop low cost methods of treating wastewater particularly that of municipal and industrial origin. Rapid industrialization has resulted in the rise of pollution. Developing low cost technology for wastewater treatment offers an alternative and has been found to be most effective for treatment of domestic and industrial wastewater by Sequencing Batch Reactors (SBR) system. Environmental degradation is an escalating problem owing to the continual expansion of industrial production and high-levels of consumption. A renewed dedication to a proven strategy to resolve this problem is needed. Cleaner Production is one such strategy, which can address this problem. It is a preventive environmental

management strategy, which promotes eliminating waste before it is created to systematically reduce overall pollution generation, and improve efficiencies of resources use.

Most industries produce some wastewater although recent trends in the developed world have been to minimise such production or recycle such wastewater within the production process. Wastewater pollution is the main issue of this sector. In pharmaceutical industries wastewater is mainly generated through the washing activities of the equipment. Though the wastewater discharged is small in volume, is highly polluted because of presence of substantial amounts of organic pollutants. Solid waste usually comprises of expired or rejected medicines, spent solvents, packaging material and damaged bottles. Level of wastewater pollution varies from industry to industry depending on the type of process and the size of the industry. Hence Effluent Treatment Plants or ETPs are used by leading companies in the textile, pharmaceutical and chemical industry to purify water and remove any toxic and non effluent-treatment-plant toxic materials or chemicals from it. These plants are used by all companies for environment protection. The ETP plants are used widely in dyeing industry to remove the effluents from the dyes and related chemicals. During the manufacturing process of dyes and from domestic wastes, varied effluents and contaminants are produced. The effluent treatment plants are used in the removal of high amount of organics, debris, dirt, grit, pollution, toxic, non-toxic materials, polymers etc. from dyes and other domestic and textile stuff.

The aim of the present research work was to determine the behaviour of various parameters of the chemical wastewater and mode of treatment by Sequencing Batch Reactors (SBR) system instead of Conventional type system. The study was conducted in a Effluent treatment plant for dyeing and domestic effluents.

OBJECTIVES

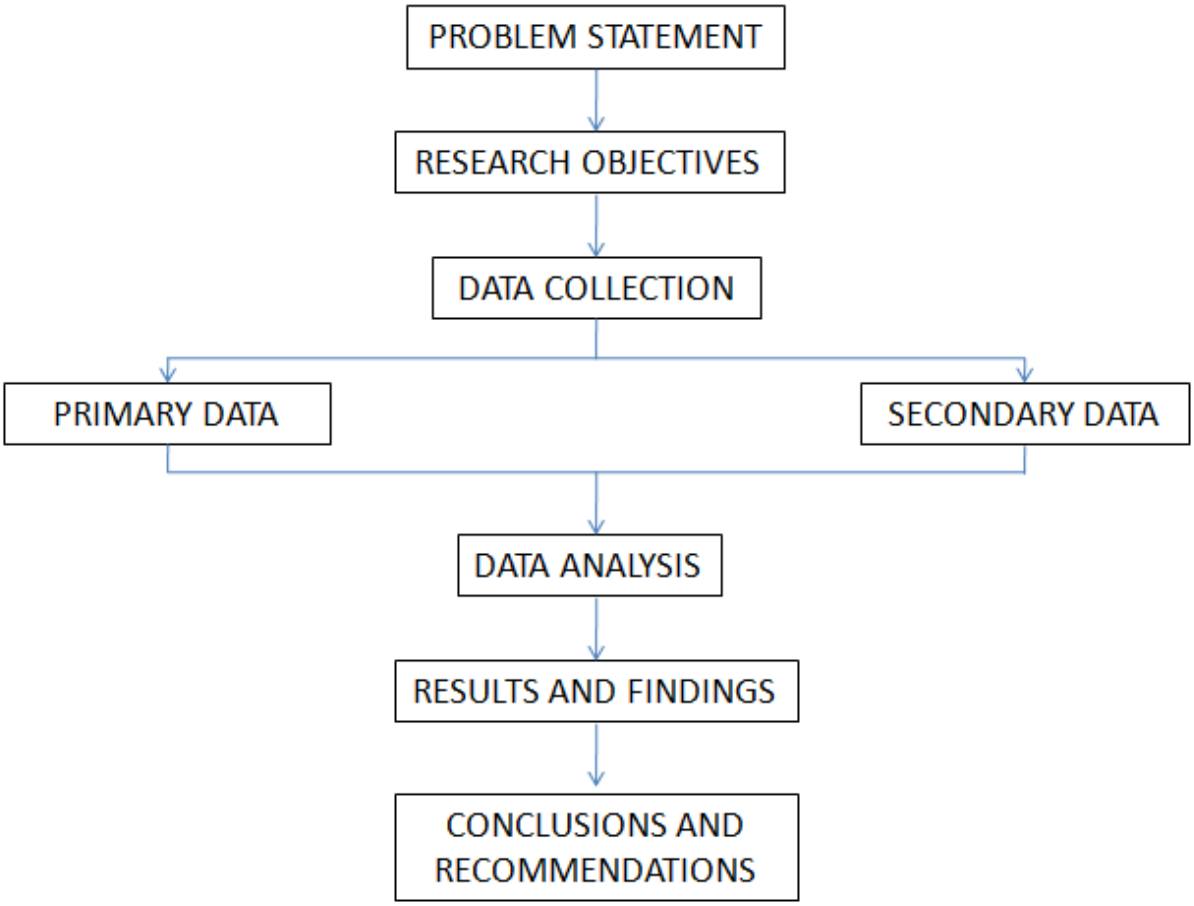
The objective of an effluent treatment is generally to allow domestic and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment. Irrigation with wastewater is both disposal and utilization and indeed is an effective form of wastewater disposal (as in slow-rate land treatment). However, some degree of treatment must normally be provided to raw municipal wastewater before it can be used for agricultural or landscape irrigation or for aquaculture. The quality of treated effluent used in agriculture has a great influence on the operation and performance of the wastewater-soil-plant or aquaculture system. In the case of irrigation, the required quality of effluent will depend on the crop or crops to be irrigated, the soil conditions and the system of effluent distribution adopted. Through crop restriction and selection of irrigation systems which minimize health risk, the degree of pre-application wastewater treatment can be reduced. A similar approach is not feasible in aquaculture systems and more reliance will have to be placed on control through wastewater treatment.

Nevertheless, there are locations where a higher-grade effluent will be necessary and it is essential that information on the performance of a wide range of wastewater treatment technology should be

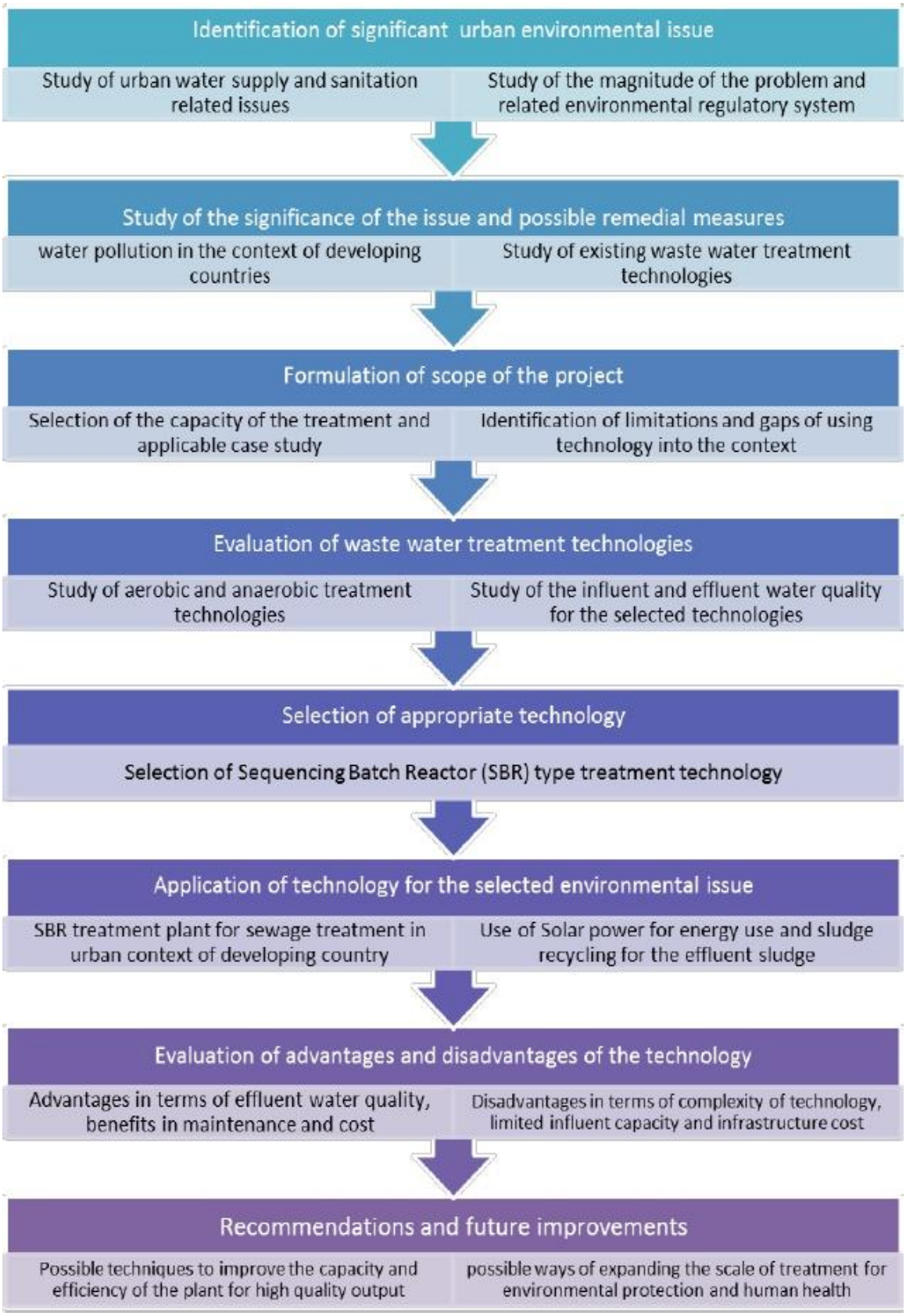
available. The design of wastewater treatment plants is usually based on the need to reduce organic and suspended solids loads to limit pollution of the environment. Although the magnitude of peaks is attenuated as wastewater passes through a treatment plant, the daily variations in flow from a municipal treatment plant make it impracticable, in most cases, to irrigate with effluent directly from the treatment plant. Some form of flow equalization or short-term storage of treated effluent is necessary to provide a relatively constant supply of reclaimed water for efficient irrigation, although additional benefits result from storage.

2. RESEARCH METHODOLOGY

- Identification of significant urban environmental issue
- Study the significance of the issue and possible remedial measures
- Formulation of scope of the project
- Evaluation of waste water treatment technologies
- Selection of appropriate technology
- Application of technology for the selected environmental issue
- Evaluation of advantages and disadvantages of technology
- Recommendations and future improvements



The Primary data are collected through direct interviews and questionnaires with the Employees, Management. The Secondary data are collected from the Literature review (books, Articles, Journals, Publishing's, etc.)



3.EXPERIMENTATION

3.1TREATMENT METHODS:

The objective of preliminary treatment is the removal of coarse solids and other large materials often found in raw wastewater. Removal of these materials is necessary to enhance the operation and maintenance of subsequent treatment units. Preliminary treatment operations typically include coarse screening, grit removal and, in some cases, combination of large objects. In grit chambers, the velocity of the water through the chamber is maintained sufficiently high, or air is used, so as to prevent the settling of most organic solids. Grit removal is not included as a preliminary treatment step in most small wastewater treatment plants. Comminutes are sometimes adopted to supplement coarse screening and serve to reduce the size of large particles so that they will be removed in the form of a sludge in subsequent treatment processes. Flow measurement devices, often standing-wave flumes, are always included at the preliminary treatment stage.

3.1.1 PRIMARY TREATMENT

The objective of primary treatment is the removal of settle-able organic and inorganic solids by sedimentation, and the removal of materials that will float (scum) by skimming. Approximately 25 to 50% of the incoming biochemical oxygen demand (BOD5), 50 to 70% of the total suspended solids (SS), and 65% of the oil and grease are removed during primary treatment. Some organic nitrogen, organic phosphorus, and heavy metals associated with solids are also removed during primary sedimentation but colloidal and dissolved constituents are not affected. The effluent from primary sedimentation units is referred to as primary effluent. Table 12 provides information on primary effluent from three sewage treatment plants in California along with data on the raw wastewaters. primary treatment is the minimum level of pre-application treatment required for wastewater irrigation. It may be considered sufficient treatment if the wastewater is used to irrigate crops that are not consumed by humans or to irrigate orchards, vineyards, and some processed food crops. However, to prevent potential nuisance conditions in storage or flow-equalizing reservoirs, some form of secondary treatment is normally required in these countries, even in the case of non-food crop irrigation. It may be possible to use at least a portion of primary effluent for irrigation if off-line storage is provided. Primary sedimentation tanks or clarifiers may be round or rectangular basins, typically 3 to 5 m deep, with hydraulic retention time between 2 and 3 hours. Settled solids (primary sludge) are normally removed from the bottom of tanks by sludge rakes that scrape the sludge to a central well from which it is pumped to sludge processing units. Scum is swept across the tank surface by water jets or mechanical means from which it is also pumped to sludge processing units.

3.1.2 SECONDARY TREATMENT

The objective of secondary treatment is the further treatment of the effluent from primary treatment to remove the residual organics and suspended solids. In most cases, secondary treatment follows primary treatment and involves the removal of biodegradable dissolved and colloidal organic matter using aerobic biological treatment processes. Aerobic biological treatment (see Box) is performed in the presence of oxygen by aerobic microorganisms (principally bacteria) that metabolize the organic matter in the wastewater, thereby producing more microorganisms and inorganic end-products (principally CO_2, NH_3, and H_2O). Several aerobic biological processes are used for secondary treatment differing primarily in the manner in which oxygen is supplied to the microorganisms and in the rate at which organisms metabolize the organic matter.

High-rate biological processes are characterized by relatively small reactor volumes and high concentrations of microorganisms compared with low rate processes. Consequently, the growth rate of new organisms is much greater in high-rate systems because of the well controlled environment. The microorganisms must be separated from the treated wastewater by sedimentation to produce clarified secondary effluent. The sedimentation tanks used in secondary treatment, often referred to as secondary clarifiers, operate in the same basic manner as the primary clarifiers described previously. The biological solids removed during secondary sedimentation, called secondary or biological sludge, are normally combined with primary sludge for sludge processing.

In the activated sludge process, the dispersed-growth reactor is an aeration tank or basin containing a suspension of the wastewater and microorganisms, the mixed liquor. The contents of the aeration tank are mixed vigorously by aeration devices which also supply oxygen to the biological suspension. Aeration devices commonly used include submerged diffusers that release compressed air and mechanical surface aerators that introduce air by agitating the liquid surface. Hydraulic retention time in the aeration tanks usually ranges from 3 to 8 hours but can be higher with high BOD5 wastewaters. Following the aeration step, the microorganisms are separated from the liquid by sedimentation and the clarified liquid is secondary effluent. A portion of the biological sludge is recycled to the aeration basin to maintain a high mixed-liquor suspended solids (MLSS) level. The remainder is removed from the process and sent to sludge processing to maintain a relatively constant concentration of microorganisms in the system. Several variations of the basic activated sludge process, such as extended aeration and oxidation ditches, are in common use, but the principles are similar.

Biological process is one of the old and conventional treatment systems for waste water and sewage treatment. Main purpose of this treatment is for the reduction of biochemical oxygen demands (BOD) and chemical oxygen demand (COD). This process refers to a mass of microorganisms cultivated in the treatment process to break down organic matter into carbon dioxide, water, and other inorganic compounds or bio gas. In biological processes, various types of microbes and bacteria are used that digest the waste materials. In order to separate the contaminants from the water, growth of the microbe population is brought to a point that will be sufficient to digest the pollutants in a given time span.

The biological systems works is a complex ecosystem of competing organisms. The dominant organisms are the bacteria, of which there may be 300 species present. The bacteria use the ingested molecules for the synthesis of new molecules, in the process of growth. When they have reached normal size, the bacterium divides into two, and the process is repeated. Although there are many thousands of chemical reactions involved in the metabolism of a bacterium, three major processes that are relevant to the biological treatment. These are:

- Ingestion
- Respiration
- Growth and division

Most of the aerobic process , oxygen is used for respiration & growth. Initially the bacteria culture to be introduced into the system still stabilization to maintain the required level. The aerobic bacteria are introduced into the system though enzymes if necessary or naturally. Once the water is enters the aeration tank, the fine particulates, colloidal particles and large molecules, become entangled with, and adsorbed to, the flock material which basically consist of active bacteria. However, for the bacteria living on the inside of the flock, oxygen availability may be problem because water has such a low capacity for oxygen storage. The oxygen input of the aeration system must effectively match the uptake of oxygen through microbial respiration. The rate of microbial respiration is directly related to the rate of substrate oxidation, which in turn is dependent on the sludge age at which the activated sludge process is operated, the mixed liquor temperature, the influent wastewater load and its composition. Hence, the oxygen has to diffuse along a concentration gradient from the wastewater through the flock material to the inside.

The process oxygen demand is made up of two components, a carbonaceous component, which is BOD-dependent, and a nitrogenous component, related to nitrification/de-nitrification processes. Aerobic microorganisms are cultured in the aeration tanks and an MLSS level of 3000- 5000 to be maintained in the Aeration tank on regular basis. The oxygen requirement of the aerobic system can be met with various methods of Aeration.

Aeration is the process by which compressed air is forced through a liquid or substance, normally from the bottom of a tank, in order to reach a certain level of dissolved oxygen concentration. Aeration systems normally perform two functions in activated sludge wastewater treatment processes, namely, oxygen transfer and mixing. While oxygen transfer may be regarded as the primary function, mixing is also important to ensure a full utilization of the activated sludge reactor volume and a uniform dispersion of dissolved oxygen throughout the mixed liquor. A diffused air system introduces compressed air through a perforated membrane into the wastewater. In diffused air systems, air is introduced to the mixed liquor through “diffusers”, located at some distance below the liquor surface. Diffusers are classified by the physical characteristics of the equipment, or by the size of the air bubble. The choice of bubble size, diffuser type, and diffuser placement can have a great effect on the efficiency of the aeration process. The air bubble stream emitted from a submerged diffuser exerts an air-lift pumping effect on the surrounding liquid, generating a pattern of vertical circulation, which has an important influence on oxygen transfer.

Where the diffusers are uniformly distributed over the tank floor area, the air-lift pumping effect is minimized, thus maximizing air bubble/water contact time and oxygen transfer efficiency.

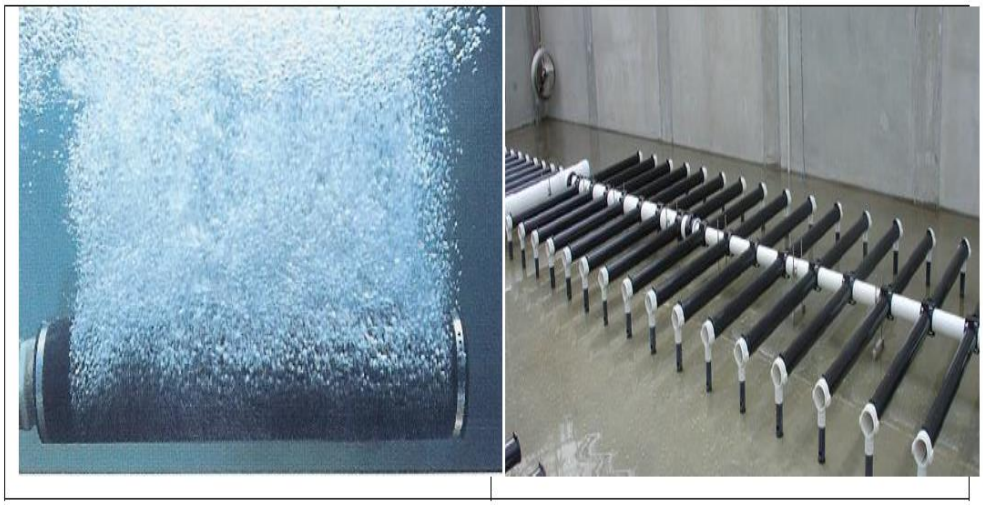


Fig: Diffuser system

3.1.3 TERTIARY TREATMENT

Tertiary and/or advanced wastewater treatment is employed when specific wastewater constituents which cannot be removed by secondary treatment must be removed. Individual treatment processes are necessary to remove nitrogen, phosphorus, additional suspended solids, refractory organics, heavy metals and dissolved solids. Because advanced treatment usually follows high-rate secondary treatment, it is sometimes referred to as tertiary treatment. However, advanced treatment processes are sometimes combined with primary or secondary treatment (e.g., chemical addition to primary clarifiers or aeration basins to remove phosphorus) or used in place of secondary treatment

Pressure sand Filter: Filtration is the process of removal of suspended solids from the water. The filtration of suspended solids by occlusion removes particles based on size. Conventional filtration consists of passing the water usually downward, through a media where the suspended solids get removed. Adsorption and starving are the general filtration mechanisms involved in the removal of suspended solids. The suspended solids due to its affinity to the filter media and the large surface area of the media get adsorbed on the surface of the media. Suspended Particles are occluded, or held back, due to their inability to pass through the pores of barrier of some sort. The barrier might be a packed bed of sand. Filtration by occlusion is often called “surface filtration”, since it occurs on the surface of the filtering media. When water flows downward through the sand, which is the traditional path, the suspended matter is held in the “VOIDS” between the filtering granules, mostly in the top of the bed. The accumulating load of the suspended matter in the bed causes an increasing loss of pressure during the filter run. When this loss

reaches a determined limit, the filter is backwashed upward, discharging the suspend load out to the drain. During backwash cycle, the filter bed is lifted and fluidized to remove accumulated particles. After the backwash cycle, the filter bed is allowed to settle. While it settles, the filter bed media will classify with the heaviest media particles settling first, and the lightest particles settling on the top.

Different types of filter media are used to remove suspended solids, the most common is sand, but anthracite is also widely used. The equipment that performs the filtration task is called as filters and normally working with pressure and called pressure sand filter. Pressure filters are in closed, round steel shells and functions under the pressure of the incoming water. Pressure filters are the preferred type for many industrial applications, because they have shells of lower height, can be operated to run longer between successive backwashing and can operate at higher flow rates. Pressure filter used the filter media had to be supported by a media, which is generally called as supporting media to prevent the filter media escaping out from the filter. The most widely used supporting media in industries is pebbles and sylex. The supporting media should be heavier than the filter media so that it settles always at the bottom after every backwash.

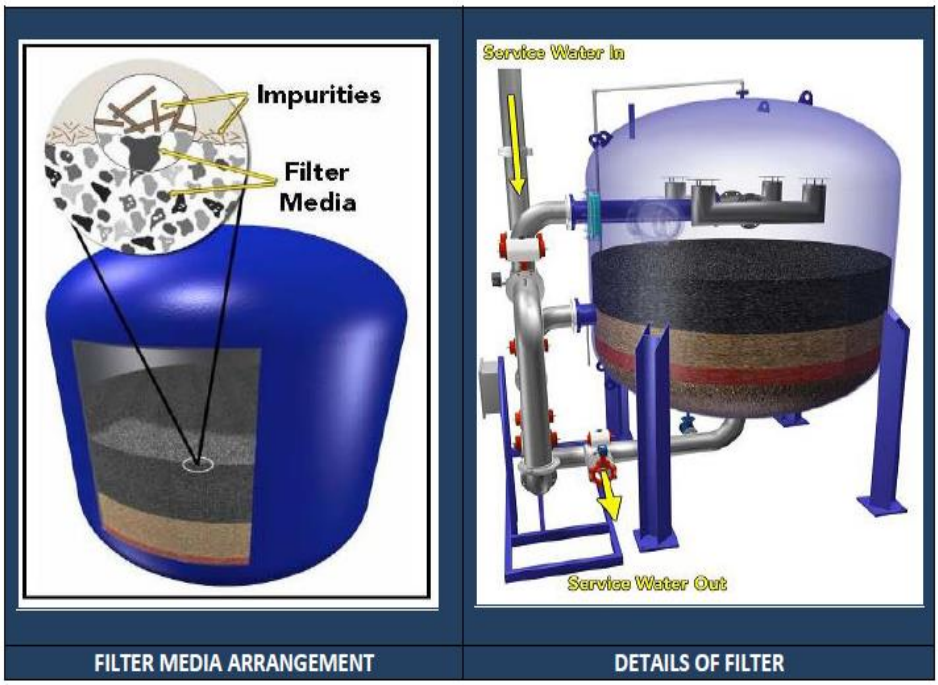


Fig: Filter media arrangements

Activated Carbon Filter: Activated carbon is a special form of carbon that is produced by heating organic material (such as coconut shells, walnut shells or coal) in the absence of oxygen. The heat removes trapped moisture and gases and pyrolizes most of the organic material. It also leaves the remaining material with a slightly positive surface charge. An activated carbon bed can remove chlorine, small suspended particles, and colloidal particles and dissolved organics due to its ability to adsorb or electro statically hold particles. These particles would pass between the grains of carbon if not for the weak electrostatic attraction between the positive surface charge of the carbon and the negative surface charge of

the particles. Particles can also be trapped in the porous structure of the activated carbon where they are then weakly held.

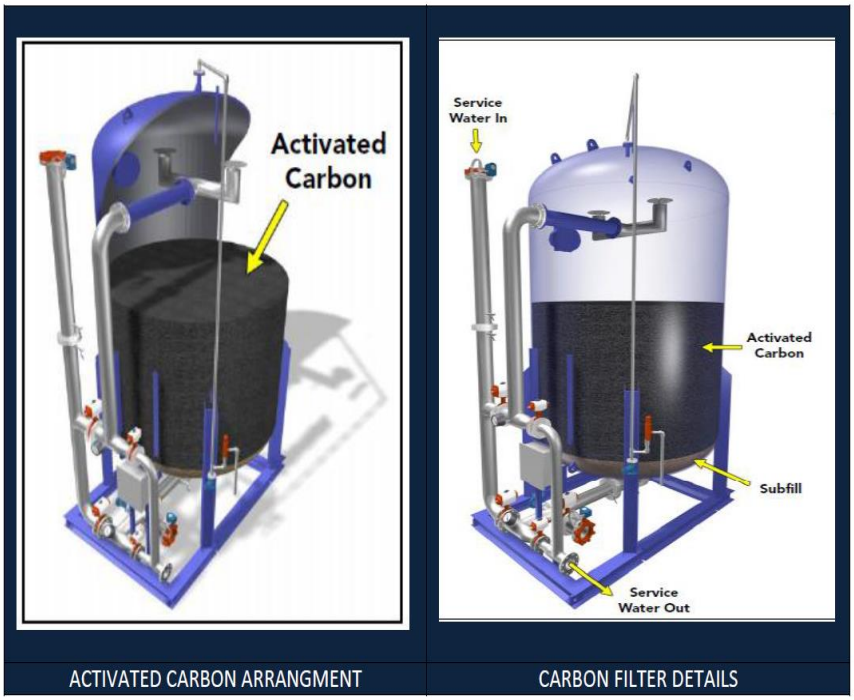


Fig: Activated carbon arrangement

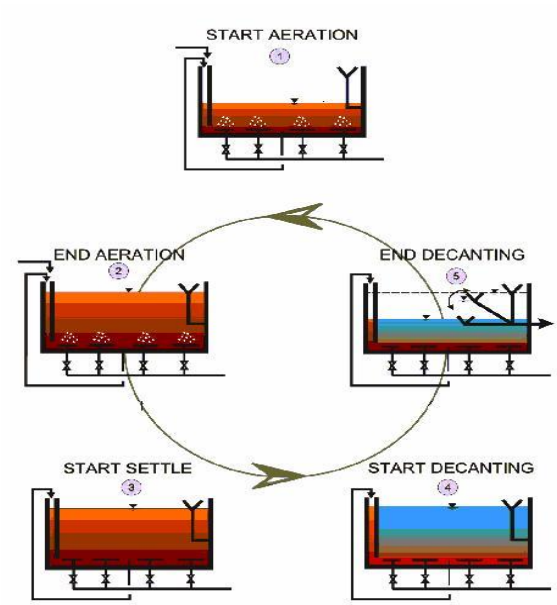


Fig: Typical cycle of SBR

3.2 EXPLANATION OF SBR CYCLE

A basic cycle comprises:

- Fill-Aeration (F/A)
- Settlement (S)
- Decanting (D)

3.2.1 TYPICAL CYCLE

During the period of a cycle, the liquid is filled in the SBR Basin up to a set operating water level. Aeration Blowers are started for aeration of the effluent. After the aeration cycle, the biomass settles under perfect settling conditions. Once Settled the supernatant is removed from the top using a DECANTER. Solids are wasted from the tanks during the decanting phase.

These phases in a sequence constitute a cycle, which is then repeated.

Chlorine Contact Tank:

The Effluent from the SBR basins will be collected in Chlorine Contact Tank .The supernatant thus collected will get disinfected in Chlorine Contact Tank by adding suitable dose of chlorine and finally it is discharged in to nearby basin.

Sludge Handling System:

The sludge as collected from SBR basins is collected into sludge sump and conveyed to centrifuge unit for dewatering the same. The necessary centrifuge feed pumps & Centrifuges will be provided. There will be an arrangement of dosing polyelectrolyte if necessary. Used the term of 'Sequencing Batch Reactor' for a Single basin reactor for the full scale treatment of an industrial wastewater.

- **DNPAO in Sludge:**

The SBR has not been applied to the simultaneous nitrogen and phosphorus removal process, such as conventional A2O (anaerobic/anoxic/aerobic) process, which uses phosphate-accumulating organisms (PAOs), nitrifier and denitrifier, because the circulation of liquid that contains nitrate and nitrite is necessary in this process. If denitrification can be attained without any carbon substrate under anoxic condition, the circulation of liquid from aerobic to anoxic phases is unnecessary and thus nitrogen and phosphorus can be removed in a single SBR. To realize this process, we propose to use denitrifying phosphate-accumulating organisms (DNPAOs) in the SBR. DNPAOs have metabolic characteristics similar to those of PAOs, based on the metabolic transformations responsible for enhanced biological

phosphorus removal (EBPR) [2–6]. In a similar manner as PAOs, DNPAOs take up external carbon substrates and store as polyhydroxyalkanoates (PHAs) in the cell under anaerobic conditions. However, they can

utilize nitrite or nitrate instead of oxygen as an electron acceptor to remove phosphorus without any extra cellar carbon substrates under anoxic conditions. nitrogen and phosphorus removal in the AOA process using an SBR and the fraction of DNPAOs in the sludge, both of which depend on the amount of carbon substrate added at the start of aerobic conditions.

- **Microbial Absorption:**

There are several kinds of microorganisms which adsorb both organic and inorganic matter from wastewater. The adsorption capacity depends on the physical, chemical and biological conditions. Lead, Cadmium and Copper could be adsorbed onto the surface of cell membrane of *Aspergillus niger*. *Candida utilis* could adsorb Zinc. The Cadmium adsorption capacity of *Chlorella pyrenoidosa* was induced with light exposure. The heavy metal adsorption capacity of dead *mycelium* of fungi, *Penicillium spnulosum*, *Aspergillus niger* and *Trichloderma sp*. increased with the increase of solution pH. Zinc adsorption yield of dead *mycelium* of *Penicillium sp*. also decreased with the increase of temperature.. The concentration of the heavy metals in the wastewater could be reduced

by the activated sludge process. But several problems occur during operation of an activated sludge system such as the fluctuation of effluent quality and bio-sludge quality. Sequencing batch reactor (SBR) systems might be used due to their high mixed liquor

suspended solids (MLSS) content and resistance to the shock load and toxic substances.

In this study, the adsorption capacities of both resting and autoclaved bio-sludges were studied. The stability of Cu2+ and Zn2+ adsorption capacities of bio-sludge after washing with various kinds of solution were determined. Finally, the adsorption capacities of bio-sludge for organic matter and heavy metals in the SBR system under various MLSS concentrations were investigated.

- **Microbial synthesis as a function of SRT :**

When the SBR system is operated normally with appropriate control of anoxic, anaerobic and aerobic conditions in each period, denitrification occurs under anoxic conditions, uptake of organic matter and discharge of phosphorus takes place under anaerobic conditions, and oxidation of organic matter, uptake of phosphorus, and nitrification occur under aerobic conditions. In the SBR system, sludge retention time (SRT) is a significant

factor affecting the mixed liquor suspended solids (MLSS) and food/microorganism (F/M) ratio in biological wastewater, which controls the microbial characteristics and removal efficiencies of nutrients. increased SRT in the SBR system enhanced the removal efficiencies of organic matter, perhaps as a consequence of increased microbial populations, but reduced the removal efficiency of phosphorus by diminution of wasted sludge including phosphorus, and resulted in difficulties in the treatment and disposal of

sludge due to increased sludge volume in the system.

- **Granular Activated Carbon Bio-film:**

GAC (Extra Pure, LOBA Chemicals, Mumbai) of size ~1.5mm was used as suspended carrier medium for the aerobic biofilm formation (bulk density: 40 g/100 ml; residue on
ignition (600 °C): 5%; loss of drying (120 °C): 10%). GAC as fed to the mixed liquor of the reactor at a rate of 40 g/l of the reactor volume. During the reactor operation, the GAC was neither replaced nor regenerated. GAC-biofilm configuration operated in sequencing batch mode in aerobic condition was studied for the treatment of composite chemical wastewater. The reactor was fabricated in the laboratory using perplex glass column with a total working volume of 1.7 l capacity. The reactor had height/internal diameter (*H*/i.d.) ratio of ~3 (*H*: 0.22m and i.d.: 0.07 m). Schematic detail of the reactor along with the experimental setup is depicted in Fig. 1. The reactor outlet used for wastewater withdrawal was provided at a height of 0.045m from bottom of the reactor. This arrangement prevents loss of GAC and biomass in the reactor after the settling phase. About 0.39 l of mixed liquor was present in the reactor after the withdrawal phase was completed resulting in a total liquid volume of 1.34 l during the reaction phase. Upflow velocity of 0.083mh−1 was maintained during the reactor operation by recirculation and air sparging in the upflow mode. This velocity was found to be sufficient to keep carrier GAC in suspension during reaction phase of the reactor operation. Feeding, recirculation and decant operations were done with the help of peristaltic pumps employing preprogrammed timers.

- **Redox reaction on sludge:**

Reactors achieved stable carbon removal and nitrification. Nitrification. All reactors achieved stable carbon oxidation and there were no significant differences in carbon removal performance ($p > 0.2$ in all comparisons), which averaged 93 ± 2% COD removal. Cross-cycle sampling indicated that NPOC was consumed rapidly in the first30 min in all reactors. The reactors were operated as SBRs, and therefore achieved a concentration gradient across there action cycle which allowed for floc formers to sequester most of the organic carbon and prevent the proliferation of filamentous organisms, similar to how a selector functions [30]. A study on full-scale and lab-scale systems that used low DO treatment found that limited filamentous bulking resulted in lower effluent suspended solids than conditions with no bulking [31]. These results suggest that DO control and appropriate management of filamentous bacterial growth, substantial energy savings are possible by reducing DO levels while still achieving water quality goals typical for secondary effluents.

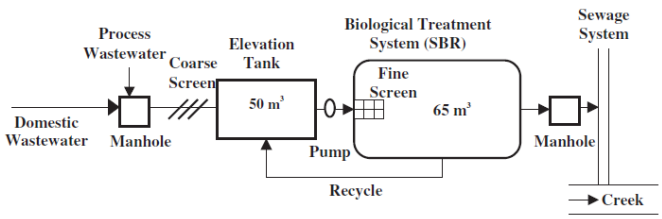


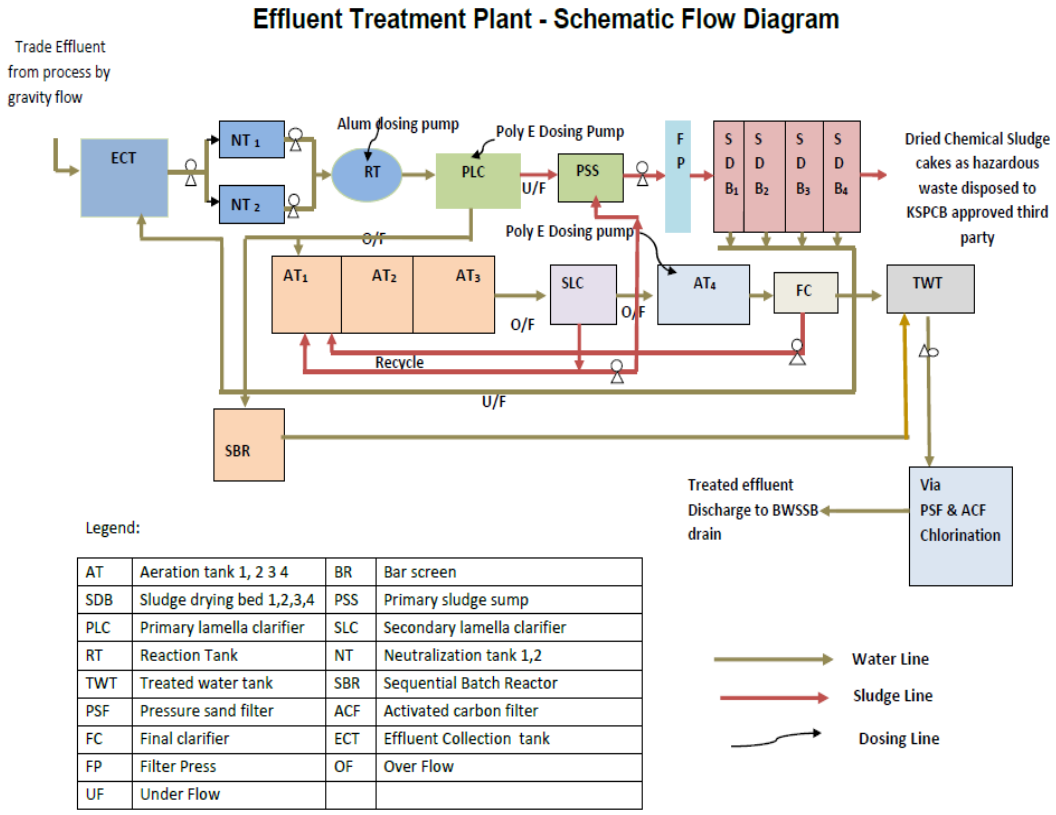
Fig: Effluent treatment flowchart

3.3 ECONOMIC FEASIBILITY

An affordable technology is the primary consideration for people to choose the product, particularly in the developing countries with comparatively low financial strength. SBR with low maintenance cost and space requirements can be a solution and even preference to tackle wastewater, however high capital cost during installation, this technology is much cheaper and affordable for community in long run. There are number of cost factors to be considered in designing of waste water treatment facility for any urban area. Design, construction and operation of SBR type sewage treatment involves following cost features.

The expected benefits for the community are ranging from socio-economic to environmental aspects. The most important benefit is in terms of health and hygiene. Sewage treatment reduces the water contamination and clean waters mean the reduction of health expenditure for the community. As the urban underserved communities consist of children aged 5 years or below prone to number of water borne diseases, health savings from treatment plant installation can lead to better living standards too.

3.4 EFFLUENT TREATMENT PLANT –



AT	Aeration tank 1, 2 3 4	BR	Bar screen
SDB	Sludge drying bed 1,2,3,4	PSS	Primary sludge sump
PLC	Primary lamella clarifier	SLC	Secondary lamella clarifier
RT	Reaction Tank	NT	Neutralization tank 1,2
TWT	Treated water tank	SBR	Sequential Batch Reactor
PSF	Pressure sand filter	ACF	Activated carbon filter
FC	Final clarifier	ECT	Effluent Collection tank
FP	Filter Press	OF	Over Flow
UF	Under Flow		

Fig: Effluent Treatment Plant - Schematic Flow Diagram

4. RESULTS AND DISCUSSION

In Phase 1, information from 75 municipal SBR facilities was compiled using the responses submitted by plant operators and suppliers, and from plant visits. The distribution of the responses was:

- Information from 12 facilities was compiled during site visits.
- Information from 29 facilities was sent directly by SBR suppliers (using the questionnaire and/or plant operating data sheets).
- Information from 34 facilities was supplied by plant staff (using the questionnaire and/or through phone and e-mail communications)

The visits to the US facilities augmented Ontario's experience with SBRs and provided data from SBR suppliers that are currently not present in the Ontario market.

Achievable effluent quality

One of the objectives of the project was to evaluate the capacity of SBR facilities to achieve different sets of effluent requirements. To achieve this goal, the facilities assessed were classified by achievable effluent quality in three groups, based on three sets of effluent limits defined with the Technical Steering Committee:

Limit 1: Conventional limit
CBOD5 = 25 mg/L TSS = 25 mg/L Annual
TP = 1 mg/L Monthly

Limit 2: Conventional w/nitrification requirements – All Monthly
CBOD5 = 10 mg/L TSS = 10 mg/L TP = 0.5 mg/L
NH3-N = 3 mg/L (summer) 5 mg/L (winter)

Limit 3: BNR/RAP-type limit – All Monthly
CBOD5 = 5 mg/L, TSS = 5 mg/L,
TP = 0.2 mg/L, and
TN = 5 mg/L (summer) 10 mg/L (winter) NH3-N = 2 mg/L (summer) 4 mg/L (winter)

Many of the plants evaluated do not have to meet the effluent phosphorus criteria shown in these limits. For this reason, many plants reaching good levels of nitrification, BOD, SS, and nitrogen removal, but not achieving the effluent P levels specified, were classified within less stringent limits. For example, plants meeting Limit 3 criteria for CBOD5, TSS, NH3-N and TN, were classified within Limit 2 because their effluent P concentrations were within the value stated for Limit 2.

5. CONCLUSION & SCOPE OF FUTURE

The number of SBR plants is growing at a fast pace. Unlike continuous flow activated sludge systems, there was little well documented evidence on SBR performance, costs, reliability, and optimal design and operations.

During Phase 1 of this program, the authors found that SBRs are cost-effective treatment systems that tend to meet and exceed their effluent criteria.

However, in spite of excellent removal rates and effluent limit compliance achieved by the SBR facilities evaluated, there is still room for optimization.

The development of a guideline manual with standards for selection, design, evaluation, and operation of SBRs should be a priority as the number of SBR plants in general is continuously increasing. Phase 3 of this program will tackle this task.

From the list of concerns compiled, lack of proper operator training has the largest impact on operating costs and effluent quality. The development of SBR operator training programs to complement traditional activated sludge operator training with SBR-specific theoretical and practical concepts should be addressed. A methodology to evaluate the actual treatment capacity of existing SBR plants should be developed. Operation strategies for process optimization should be investigated. These two tasks will be addressed in Phase 2 of this program for Evaluation & Optimization of Design/Operation of SBRs for Wastewater Treatment.

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