Removal of effluents (BOD, COD, TSS, TN, TP, FC) by using various treatment technologies

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ABSTRACT

Water is an essential substance upon which all sorts of life depend. About 75% of the Earth's surface is covered by water. At the beginning of 21st century, the world faces a water quality crisis, caused by continuous population growth, industrialization, food production practices, increased living standard and poor water use strategies. Wastewater contains pathogens (bacteria),organic&inorganic substances, animal like protozoa, insects, macro solids, gases H_2S, CO_2 emulsions and toxins (pesticides).Wastewater management has a direct impact on the biological diversity of aquatic ecosystems disrupting the fundamental integrity of our life support system. It is essential that wastewater management is considered as part of integrated ecosystem-based management that operates across sectors and borders. During past two decades several new sewage treatment technologies have been developed. Some of the technologies are FAB, AF, EGSB, SBR, MBR, SAFF, BIOFOR & UASB. The number of evaluated systems studied, the average influent flow, the mean concentration of raw and treated wastewater and the mean removal efficiency associated with many treatments technology such as (ST+ AF),(FP&AP + FP) showed systematically much higher concentration for all constituents except faecal coliforms.

Keywords: FAB-Fluidized Aerated Bed Reactor, AF- Anaerobic Filter,EGSB-Expanded Granular Sludge Blanket, SBR- Sequencing Batch Reactor,MBR- Membrane Bio Reactor,SAFF- Submerged Aeration Fixed Film Reactor, BIOFOR–BiologicalFilter Oxygenated Reactor,UASB-Up flow Anaerobic Sludge Blanket Process,ST+AF – Septic

Tank+ Anaerobic Filter,FP–Facultative Pond, BOD-Biochemical Oxygen Demand, COD- Chemical Oxygen Demand, TSS- Total Suspended Solids,

INTRODUCTION

The chief sources of water are surface water, groundwater, seawater and rainwater [1]. Surface water is exposed to different contaminants such as animal waste, pesticides, insecticides, industrial waste and many organic materials [2]. Groundwater is not as easily contaminated but once it is contaminated the full remediation and recovery is not easily achieved. Seawater makes up 97% of global water inventory a large portion is constitute as ocean ice. The average salinity of sea water is 35% by weight. Rain is a major component of water cycle and is responsible for depositing most of freshwater on the earth. Freshwater is a basic natural resource which sustains life and provides for various social and economic needs. Water is critical for the health of both human and ecological system and an important element in many of our recreational and economic activities. The Union Ministry of India for Water Resources has estimated the **country's water requirement** to be around 1093 BCM by the year 2025 and 1447 BCM by the year 2050. With projected population growth of 1.4 billion by 2050, the total available water resources would barely match 33% of the total water requirement of the country [3]. The facts indicate that India is expected to become 'water stressed' by 2025 and 'water scarce' by 2050. The National Commission for Integrated Water Resources Development (NCIWRD) has estimated that against the total annual availability of 1953 BCM [4]. The mainly water uses in agriculture, domestic supply, industrial supply, animal supply, preservation of aquatic life, recreation and leisure, generation of electricity and dilution and transport of wastes. The sources of wastewater are human waste, cesspit leakage, septic tank discharge, sewage treatment plant discharge [5], washing water, rainfall [6] collected on roof, highway drainage, blackwater, industrial waste, organic or biodegradable waste, agricultural drainage and solid and emulsions. Municipal wastewater is mainly comprised of water together with relatively small concentration of suspended and dissolved organic and inorganic solid. Among the organic substance present in sewage are carbohydrates, lignin, fats of synthetic detergent, protein and their decomposition products, as well as various natural and synthetic organic chemicals from the process industries. Municipal wastewater contains a variety of inorganic substance from domestic and industrial sources including a number of potentially toxic elements such as arsenic, cadmium, chromium, copper, lead, mercury, zinc etc. Even if toxic material is not present in concentration likely to affect humans, they might well be at phytotoxic levels, which would limit their agriculture use. However, from the point of view of health, a very important consideration in agriculture uses of waste water, the contaminants of greatest concern are the pathogenic micro and macro-organisms. The wastewater constituents are pathogens, non-pathogenic bacteria, organic particles such feces, hair, foods, soluble organic material such as urea, fruit sugar, inorganic particles such as sand grit, metal particles, soluble inorganic such as ammonia, road salt, animals such as protozoa, insect, gases such as (H_2S, CO_2) pharmaceuticals and other hormones [7].

LITERATURE

Chartres [8] addressed the utilization of waste water in agriculture in terms of viewing waste water as an important resource that can assist in fighting the water and food crises and examined the major contaminants in waste water being used in agriculture and considers the risk forms that they pose to human health and the environment. There is need to introduce changes to the way the water and wastewater are managed if sustainable development is to be achieved. it is important to develop decentralized management strategies that reduce the use of water to transport waste, and which maximize the opportunities for local water reuse.

Moore [9] advised the introduction of water saving technology, such as toilets that flush using the displaced-air principle, will reduce water consumption and wastewater volumes to levels where a decentralized, but holistic, approach to wastewater management can be adopted. Education, dissemination and promotion of alterative sustainable waste management strategies through schools, universities and best-practice initiatives will be instrumental in enabling engineers and planners to learn of the benefits that such technology can bring to their communities.

Bdoura et al. [10] discussed several options to achieve sustainability in wastewater treatment in urban areas of the Mediterranean region. The first was by decentralizing the waste water treatment rather than installing expensive sewer systems that combine and increase the volume of the waste. The next involved choosing an appropriate treatment technology for the community where several types proposed included lagoons/wetlands, Upflow Anaerobic Sludge Blanket (UASB), and Soil Aquifer Treatment (SAT). The common characteristic of all of the described types is that they encourage "zerodischarge" technology. The reuse of the wastewater decreases the money spent on fertilizers and it is considered safe, since it has been treated for microorganisms. The urban areas of many Mediterranean countries are growing rapidly, and ecological sanitation systems must be implemented that are sustainable and have the ability to adapt and grow with the community's sanitation needs. There is still a great need in this area for research to improve or optimize the current methods of wastewater treatment.

Massoud et al. [11] provided reliable and affordable wastewater treatment in rural areas, particularly in developing countries. Centralized wastewater collection and treatment systems are costly to build and operate, especially in areas with low population densities and dispersed households. Alternatively, the decentralized approach for wastewater treatment which employs a combination of onsite and/or cluster systems is gaining more attention. While there are many impediments and challenges towards wastewater management in developing countries, these can be overcome by suitable planning and policy implementation Centralized management of the decentralized wastewater treatment systems is essential to ensure they are inspected and maintained regularly. Training programs for municipality employees are essential for the proper operation and maintenance of equipment and facilities including monitoring of wastewater quality. While there are many impediments and challenges concerning wastewater management in developing countries, these can be overcome by suitable planning and policy implementation. Institutional strengthening and administrative reforms through reduced government involvement and bureaucratic control coupled with user participation should be instituted to enable the proper and sustainable management of wastewater.

Sarah M. West [12,13] suggested that many communities want a local sustainable and affordable solution to their sewage issues. On the social Side many people in small rural communities do not want to be linked to a city Sewerage service, they want to deal with their own waste and recycle what they Can. On the economic side, providing centralized reticulated sewerage systems to Outlying communities is very expensive. Many wastewater treatment systems in the hands of the householder will eventually fail due to neglect, disdain or lack of expertise.

Richard Otis [14] explains the issue succinctly when he says, "the Problem is not that on-site systems are inadequate; it is that we have not accepted the fact that on-site: systems are treatment plants that must be designed and maintained by qualified people'. As a consequence, centrally managed watertight on-site sewage treatment systems may be the

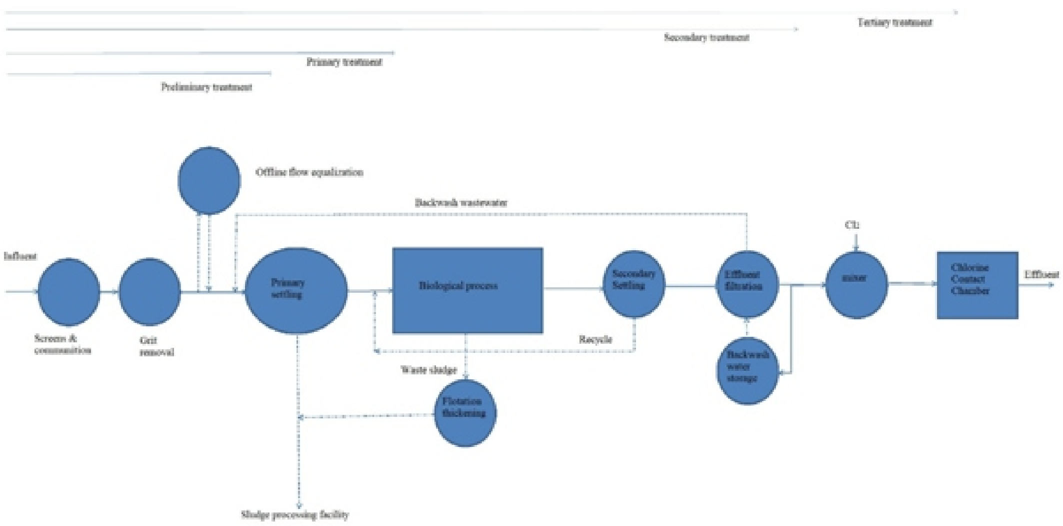
'Rolls Royce' of sewerage service in the future, but with an affordable price tag. The traditional wastewater management concept has been successfully applied over many decades in densely populated areas of industrialized countries.

Wilderer et al. [15] advocate development and application of high-tech on-site treatment plants, designed and fabricated by modern industrial methods. When mass produced, the costs for manufacturing such package plants can presumably be kept at a relatively low level. The plants should be delivered in a "user ready" state. The plant should produce an effluent which is hygienically safe and can subsequently be utilized for toilet flushing, washing clothes, cleaning floors or watering lawns. In order to keep the plants operating properly, they should be controlled by remote sensing, and maintained by specialized service enterprises. Marketing people necessarily need to do research and development of novel wastewater treatment methods in line with the actual field requirements.

PROCEDURE

In waste-water treatment plants, the unit operations and processes are grouped together in a variety of configurations to produce different levels of treatment, commonly referred to as preliminary, primary, secondary and tertiary or advanced treatment. (Figure 3)

Figure 3. Various treatment levels in a waste water treatment plant flow diagram



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1. **Preliminary treatment**: Preliminary treatment prepares waste-water influent for further treatment by reducing or eliminating non-favorable waste-water characteristics that might otherwise impede operation or excessively increase maintenance of downstream processes and equipment. These characteristics include large solids and rags, abrasive grit, odors, and, in certain cases, unacceptably high peak hydraulic or organic loadings. Preliminary treatment processes consist of physical unit operations, namely screening and comminution for the removal of debris and rags, grit removal for the elimination of coarse suspended matter, and flotation for the removal of oil and grease. Other preliminary treatment operations include flow equalization, septage handling, and odor control methods.

2. **Primary treatment**: Primary treatment involves the partial removal of suspended solids and organic matter from the wastewater by means of physical operations such as screening and sedimentation. Pre-aeration or mechanical flocculation with chemical additions can be used to enhance primary treatment. Primary treatment acts as a precursor for secondary treatment. It is aimed mainly at producing a liquid effluent suitable for downstream biological treatment and separating out solids as a sludge that can be conveniently and economically treated before ultimate disposal. The effluent from primary treatment contains a good deal of organic matter and is characterized by a relatively high BOD.

3. **Secondary treatment**: The purpose of secondary treatment is the removal of soluble and colloidal organics and suspended solids that have escaped the primary treatment. This is typically done through biological processes, namely treatment by activated sludge, fixed-film reactors, or lagoon systems and sedimentation.

4. **Tertiary/advanced waste-water treatment**: Tertiary treatment goes beyond the level of conventional secondary treatment to remove significant amounts of nitrogen, phosphorus, heavy metals, biodegradable organics, bacteria and viruses. In addition to biological nutrient removal processes, unit operations frequently used for this purpose include chemical coagulation, flocculation and Sedimentation, followed by filtration and activated carbon. Less frequently used Processes include ion exchange and reverse osmosis for specific ion removal Ob lor dissolved solids reduction.

RESULTS AND DISCUSSION

During the past two decades, several new sewage treatment technologies have been developed. Some of the technologies are fluidized Aerobic Bed (FAB), Anaerobic Filter (AF), Expanded Granular Sludge Blanket (EGSB), Sequencing Batch Reactor (SBR), Membrane Bioreactor (MBR), Fluidized Aerated Bed Reactor (FAB), Submerged

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Aeration Fixed Film Reactor (SAFF), Biological Filter Oxygenated Reactor (BIOFOR), Up flow Anaerobic Sludge Blanket (UASB) process etc. Every technology has its pros & cons and therefore has to be applied in accordance to the local conditions. Here I have presented the data of different indicator parameters and technologies obtained by various groups of researchers who are pioneer in the area of wastewater treatment technologies. [Table 1]

Table 1: Main concentration and mean removal efficiencies, according to the six treatment technologies.

Technologies			ST + TF	FD	AP + FP	AS[#]	UASB	UASB + POST[b]
Para-meter	Number of WWTP evaluated		19	73	43	13	10	8
	Average flow (m^3d^{-1})		205	400	1628	64484	3038	253
BOD	Influent (Raw)	(mgL^{-1})	665	553	510	315	371	362
	Effluent (Treated)	(mgL^{-1})	292	136	89	35	98	42
	Removal efficiency	(%)	59	75	82	85	72	88
COD	Influent (Raw)	(mgL^{-1})	1398	1187	1095	575	715	713
	Effluent (Treated)	(mgL^{-1})	730	525	309	92	251	141
	Removal efficiency	(%)	51	55	71	81	59	77
TSS	Influent (Raw)	(mgL^{-1})	479	430	411	252	289	334
	Effluent (Treated)	(mgL^{-1})	165	216	153	57	85	51
	Removal efficiency	(%)	66	48	62	76	67	82
TN[c]	Influent (Raw)	(mgL^{-1})	78	69	78	47	43	-
	Effluent (Treated)	(mgL^{-1})	61	38	45	22	48	-
	Removal efficiency	(%)	24	44	39	50	-13	-
TP	Influent (Raw)	(mgL^{-1})	9	9	11	3	7	7
	Effluent (Treated)	(mgL^{-1})	7	4	7	1	6	5

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[a] Activated sludge process includes: conventional and extended aeration.

[b] UASB+POST includes as post -treatment aerated filter, anaerobic filter, trickling filter, floating unit, facultative pond.

[c] TKN and TN are used.

[d] Geometric mean used for coliforms.

Figure 1: Mean effluent concentration for the six constituents, considering the six treatment technologies.

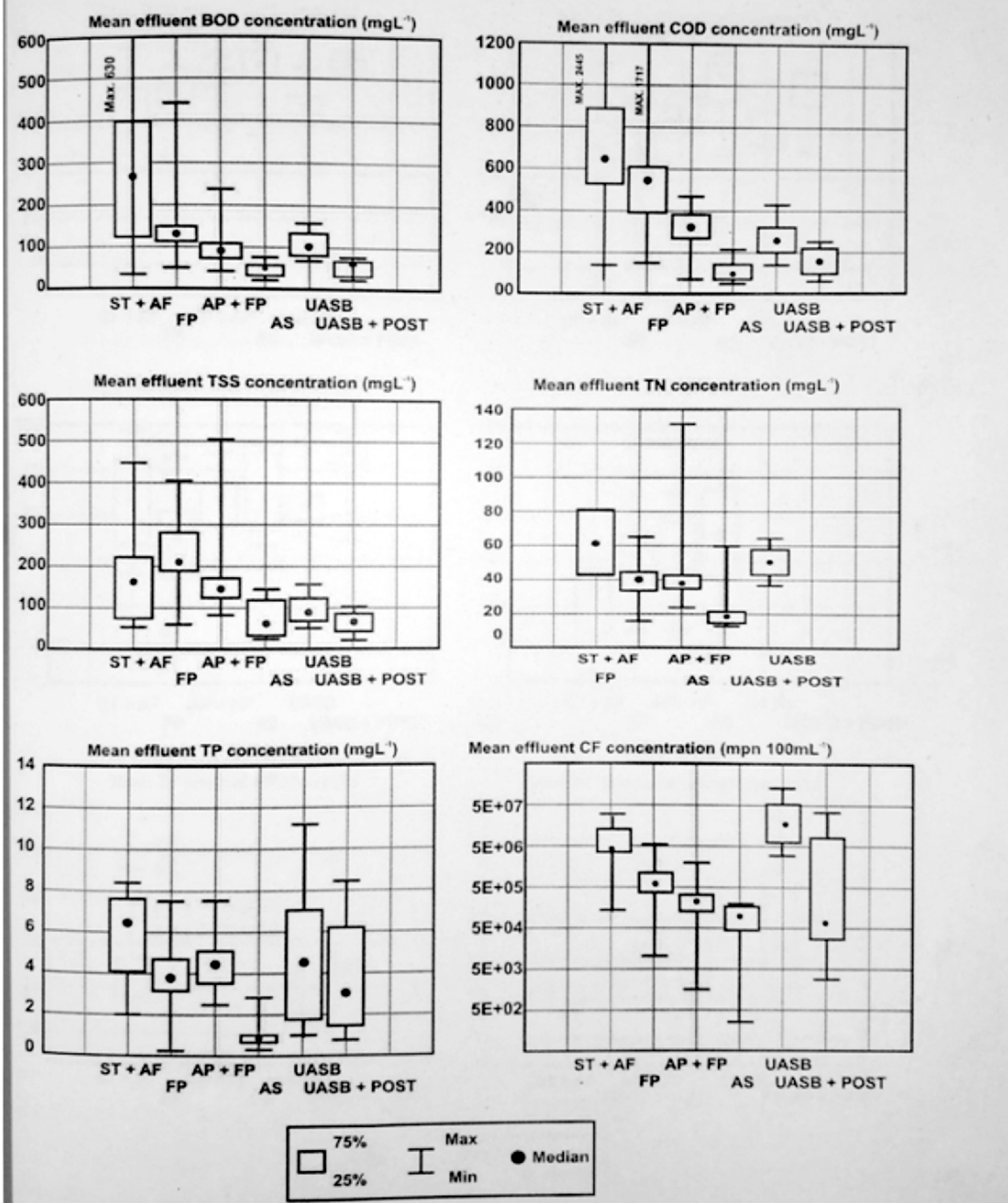

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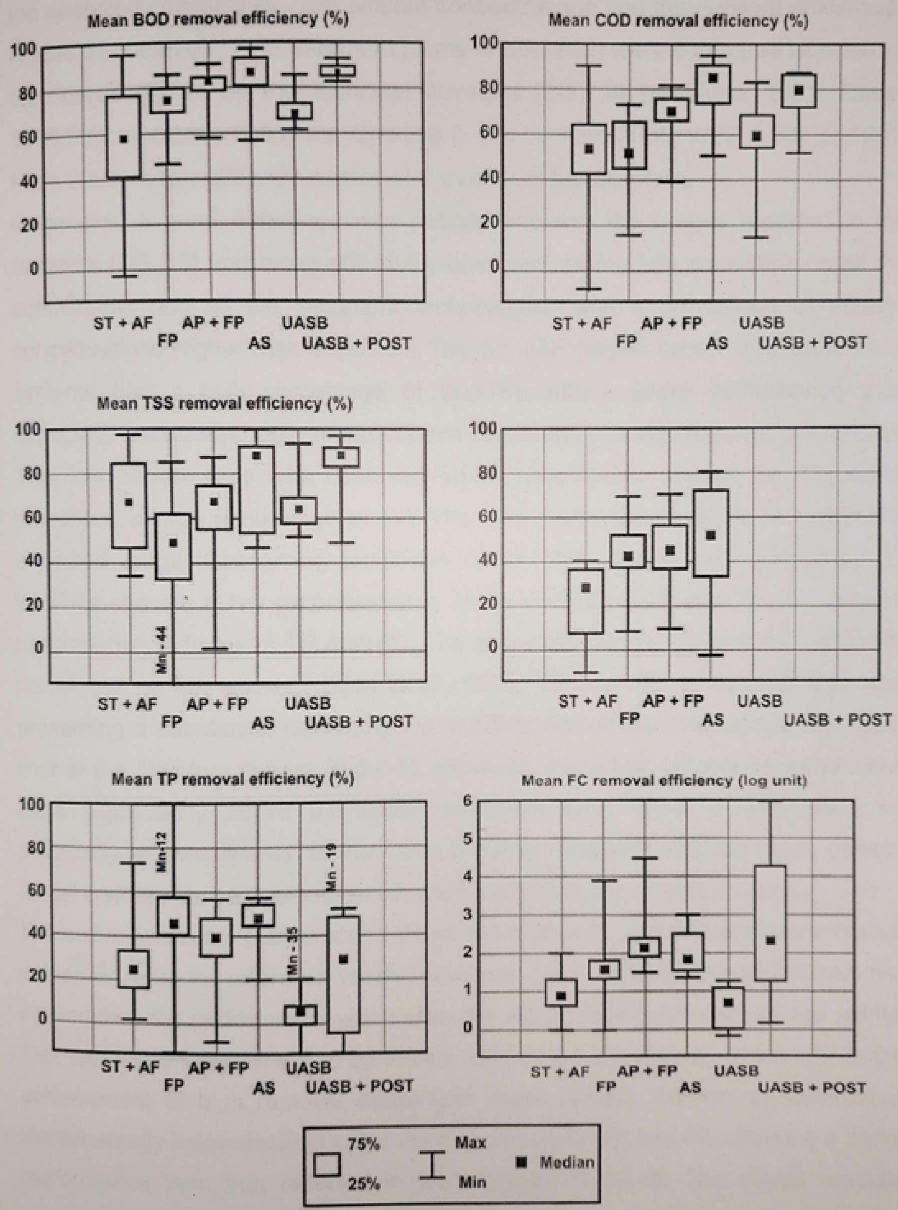
Figure 2. Mean removal efficiencies for the six constituents, considering the six treatment technologies.



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The number of evaluated systems studied by Sperling et al. [16], the average influent flow, the mean concentrations of raw and treated wastewater and the mean removal efficiencies associated with the six treatment technologies are presented in Table 1. It was observed that the influent wastewater presented a mean concentration higher than that usually reported in the literature [9-12] for prevailingly domestic wastewater. The simpler treatment systems, that is, ST+AF, FP and AP+FP, showed systematically much higher concentrations for all constituents, except faecal coli forms. Possible explanations that could justify the high concentration of raw wastewater treated by these processes could be unreported industrial contributions, low per capita water consumption, low infiltration rates and low wastewater/ water return coefficients, as discussed in more detail by Oliveira et el (2006) [17].

Performance evaluation [Figure 1and 2]

A great variability was noticed in the effluent concentrations and in the removal efficiencies, considering all analyzed constituents and all treatment technologies.

1. The septic tank + anaerobic filter (ST+AF) process presented a performance below that reported in the literature.

2.The performance of the facultative ponds (FP) was lower than expected, considering COD, TSS and TN removal efficiencies. However, good TP and FC removal efficiencies were achieved.

3. The anaerobic ponds + facultative ponds (AP+FP) showed a good performance in terms of BOD, COD, TP and FC removal, with a significant percentage of WWITPs with efficiencies within and even above the values reported by the literature.

4.The performance presented by the activated sludge (AS) plants, considering organic matter removal, was the highest among the evaluated systems, although it was below the expected one.

5.'The UASB reactors showed good BOD and COD removal efficiencies and a poor performance regarding TSS, FC and nutrients, in terms of the reference ranges reported in the literature. The performance achieved by the UASRreactors followed by post treatment (UASB +POST) was the closest one with the expected values from the literature.

Main limitations of anaerobic systems

In spite of their great advantages, anaerobic reactors hardly produce effluents that comply with usual discharge standards established by environmental agencies [18]. Therefore, the effluents from anaerobic reactors usually require a post-treatment step as a

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means to adapt the treated effluent to the requirements of the environmental legislation and protect the receiving water bodies. The main role of the post-treatment is to complete the removal of organic matter, as well as to remove constituents little affected by the anaerobic treatment, such as nutrients (N and P) and pathogenic organisms (viruses, bacteria, protozoans and helminths).

Advantages of the combined (anaerobic/aerobic) systems:

The primary sedimentation tanks, sludge thickeners and anaerobic digesters, as well as all their equipment, can be replaced with UASB reactors, which do not require the use of equipment. In this configuration, besides their main sewage treatment function, the UASB reactors also accomplish the aerobic sludge thickening and digestion functions, requiring no additional volume;

- Power consumption for aeration in activated sludge systems preceded by UASB reactors will be substantially lower compared to conventional activated sludge systems, and especially extended aeration systems;
- Thanks to the lower sludge production in anaerobic systems and to their better dewaterability, sludge volumes to be disposed of from anaerobic/aerobic systems will be much lower than those from aerobic systems alone. When the mass balance is performed, the total sludge production in a combined UASB/Trickling Filter system can be 30-50% lower than in a conventional trickling filter system.
- The construction cost of a treatment plant with UASB reactor followed by aerobic biological treatment usually amounts 50-80% of the cost of a Conventional treatment plant (20-50% investment savings). In addition, due to the simplicity, smaller sludge production and lower power consumption of the Combined anaerobic/ aerobic system, the operational costs also represent an even greater advantage. Savings on operation and maintenance costs and usually in the range of 40-50% in relation to a conventional treatment plant [19].

Conclusions:

The fundamental and practical results obtained so far have effectively contributed to consolidate the anaerobic technology as the first stage treatment for domestic and municipal sewage, and also to offer a series of posttreatment alternatives that take into account the social, economic and environmental aspects of most developing countries. Recent developments and further research on nutrient removal will soon overcome the few drawbacks that still remain, which are challenging a wider application of combined anaerobic/aerobic, anaerobic/anaerobic and anaerobic/physio-chemical systems for domestic sewage treatment.

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