ABSTRACT

The wastewater management in Brazilian coastal cities is a problem of great importance mainly in the northeast region where the states have financial constraints to implant treatment plants and to promote the proper disposal of effluents. Aracaju city is in the state of Sergipe-Brazil and represents a good example of the situation afore mentioned. It is localized in an estuarine zone drained by some open-air channels that collect about 60 percent of raw domestic wastewater discharging them in “Sergipe”, “Poxim” and “Sal” rivers. These rivers, in spite of their great economic and environmental importance, are very polluted and the aquatic life is getting more and more affected. Today, according to the local company of water and wastewater, the “DESO”, only 40 percent of domestic wastewater is treated. The treatment system adopted is based in a set of aerobic and facultative ponds installed in the northeast of city, about 10 km from downtown. In this paper we criticize the fact of many residences and other kind of buildings are still using septic tanks. This process is incompatible with places where the water table is high and suffer influence of tide motion. So, this work suggests an alternative to the wastewater management of Aracaju, decentralizing the treatment system, and presents a new process that can be used in the near future to replace the septic tanks in residential buildings, shopping-centers, etc. The process is based in fluidized bed biofilm reactor technology. The laboratory scale experiments are being developed with success.

KEYWORDS: Wastewater management, biofilm reactors, fluidized bed reactors, small plants, decentralized management systems.

INTRODUCTION

Aracaju is a Brazilian coastal city, capital of Sergipe state in Brazil. It has about 450,000 inhabitants. Most of its raw wastewater (about 60 percent) is collected by open air channels and discharged in the estuarine zone of “Sergipe”, “Poxim” and “Sal” rivers, affecting directly their related ecosystems and disturbing the urban aesthetic.

Most of the districts of Aracaju were estuarine areas in the recent past. With the City growing, some of these areas were changed into building zones. Nowadays, the peripheral zone of the city is expanding in direction to “Sergipe” and “Sal” rivers basin, giving rise to the degradation of swamp.

José Jailton Marques
Master of Science in Chemical Engineering, teacher and researcher in Environmental Engineering and Technology at Universidade Tiradentes-UNIT-Aracaju-SE-Brasil, doctor student in Chemical Engineering at UNICAMP-SP-Brazil, environmental consultant.

João Sampaio d’Ávila
Doctor of Science at COPPE-UFRJ, Emeritus Professor at UFS-São Cristóvão-SE-Brasil, teacher and researcher in Environmental Engineering and Technology at Universidade Tiradentes-UNIT-Aracaju-SE-Brasil, director of Ambientec Consultoria Ltda. - Aracaju-SE–Brazil. E-mail: ambtec@infonet.com.br

Pedro Sampaio Linhares
Master of Science in Geochemistry and Analytical Chemistry, member of American Society for Quality, retired Professor at UFBA-Salvador-BA-Brazil, teacher and researcher in Environmental Engineering and Technology at Universidade Tiradentes-UNIT-Aracaju-SE-Brasil, environmental consultant. E-mail: plinhares@infonet.com.br

José Ronaldo Oliveira
Master of Science in Chemical Engineering, environmental consultant, teacher and researcher in Chemical Engineering at Universidade Federal de Sergipe (UFS). São Cristóvão-SE-Brazil.

Endereço(1): Av. Adélia Franco, 3720. Edif. Nápoles, apto. 503. CEP: 49040-020. Luzia. Aracaju-SE-Brazil. E-mail: jmarques@netdados.com.br
Besides the problem presented above, the use of septic tanks is yet a common practice in Aracaju and other coastal cities of Northeast part of Brazil. These devices are a kind of process used to treat wastewater locally in houses and other residential buildings. The contamination of groundwater is almost unavoidable because the water table of these cities are generally very high and the geological conditions are favorable.

This work presents alternatives to improve the wastewater management system of Aracaju and many others cities in emergent coastal countries like Brazil. The main idea is the use of decentralized wastewater treatment plants to permit the water reuse and avoid the disposal of raw wastewater in the neighbor water courses, mainly in the estuarine areas, stopping the use of septic tanks.

WASTEWATER COLLECTION AND TREATMENT SYSTEMS

According to the “Companhia de Saneamento de Sergipe (DESO)”, only about 40 percent of the city is served by the wastewater collection system. It is yet a very low rate, taking in account the environmental sensitivity of the region. The another 60 percent of the wastewater are discharged in natura directly in the surrounding rivers as shown in figures 01 and 02. In the first one the area was formerly (about 40 years ago) a very beautiful landscape: The “13 de Julho” beach. In the second one, the habitat of fish, crabs and another kind of crustaceans was changed into a waste deposit. The negative impact on the river and their related ecosystems is getting more and more pronounced. The uncontrolled population growth gave raise to the crowded urban houses, the well known “favelas”.

Figure 01: Panoramic view of Aracaju city showing wastewater disposal into Poxim river. Cortesy of Líneu Foto Studio with adaptations.

The wastewater treatment system of Aracaju is centralized. Actually, it consists in a set of stabilization ponds localised about 10 kilometer away from downtown, occupying an area of 10 hectares (see Figure 03). Certainly, it was a very controversial choice of the public company of water and wastewater.
Figure 02: Open air channel discharging wastewater in an estuarine zone

Figure 03: Partial view of the wastewater treatment system of Aracaju city

ALTERNATIVES TO IMPROVE THE WASTEWATER MANAGEMENT

This work suggests some alternatives to improve the wastewater management in Aracaju and other similar cities as follow:

1 – DECENTRALIZATION OF WASTEWATER TREATMENT

We suggest the use of small decentralized plants to provide the treatment of domestic wastewater. These plants can be built in some strategic places in the City to serve portion of a community. By adopting compact design it is possible to minimize the necessary space and to ensure the opportunity to integrate the system easily in urban scenario.
According to CRITES & TCHOBANOGLOUS (1998), the objectives of small and decentralized wastewater treatment systems are:

- Protecting public health;
- Protecting the receiving environment from degradation or contamination;
- Reducing costs of treatment by retaining water and solids near their point of origin through reuse.

There are some advantages of the decentralized wastewater treatment systems:

- The investment to implant a centralized system is very high;
- The possibility of water reuse to irrigate gardens, to wash cars, to clean the yards, to clean the streets and other secondary uses is enhanced;
- The small plants can be built underground, permitting to use the cover as recreational area, for example;
- They can be designed to work in individual homes or to be used in residential buildings integrated to the local architecture (DIXON et al., 1999).

2 – THE USE OF FLUIDIZED BED BIOFILM REACTORS INSTEAD OF SEPTIC TANKS

The aerobic processes have the advantage of not to generate odour. Additionally, if we compare the activated sludge reactors with attached growth biomass reactors, the active biomass content in the second type reactors is about ten times higher than in the first ones. So, the organic matter degradation rates follow the same trend (HEIJNEM, 1993; LAZAROVA & MANEM, 1994).

The table 01 below presents a comparison between the costs and the need of area to the most important processes worldwide used to treat domestic wastewater (FAN, 1978).

<table>
<thead>
<tr>
<th>ITEM</th>
<th>ACTIVATED SLUDGE</th>
<th>FLUIDIZED BED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investments</td>
<td>I</td>
<td>0.7I</td>
</tr>
<tr>
<td>Operational costs</td>
<td>X</td>
<td>1.57X</td>
</tr>
<tr>
<td>Area</td>
<td>A</td>
<td>0.46A</td>
</tr>
</tbody>
</table>

Analyzing the table 01 it will be clear that the fluidized bed systems need only about 50 percent of the necessary area to allocate an activated sludge process with the same capacity, investing something like 30 percent less. On the other hand, the operational costs are about 60 percent higher in fluidized bed systems.

The decision between these two kinds of processes relays in an economical problem. One must keep in mind that it is necessary to treat the wastewater and protect the environment. If there is limitation of area, the verticalized processes is a possible solution.

The figure 04 shows a scheme of the fluidized bed biofilm reactor. The raw effluent and the air supply inlets are in the bottom of the equipment. The two phases are mixed, flowing upward in contact with the active biomass immobilized in inert carriers. The top of the reactor provide the separation of the three phases. The gas is released in atmosphere, the solid phase goes downward and the liquid phase goes to the sludge separation unit.

This is a novel system derived from the fluidized bed biofilm reactors. The innovation consists in the use of two solid phases as inert carriers, improving both the contact between the biomass and the liquid phase and the mass transfer in the reactor. Additional details about this process are out of the purpose of this article because the patent of the process is getting required. The process will be better discussed in a future paper.
Table 02: Geometric characteristics of fluidized bed biofilm reactor

<table>
<thead>
<tr>
<th>Item</th>
<th>Dimension (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal diameter of cylindrical part</td>
<td>6.0</td>
</tr>
<tr>
<td>Cylindrical part height</td>
<td>75.0</td>
</tr>
<tr>
<td>Conic part height</td>
<td>10.0</td>
</tr>
<tr>
<td>Superior section diameter</td>
<td>12.0</td>
</tr>
<tr>
<td>Height of cylindrical section on top of reactor</td>
<td>8.0</td>
</tr>
<tr>
<td>Free board height</td>
<td>10.0</td>
</tr>
</tbody>
</table>

The total volume of reactor is 3.83 L.

DISCUSSION

From the topics pointed out above, it is clear that the problem of wastewater management in Aracaju is serious, but the solutions exist. It is important to say that the sewer service tax represents 80 percent of the water account. This financial income can be sufficient to offer a better service to the community. The authorities must treat this question with more emphasis.

The wastewater treatment system today used (stabilization ponds) is controversial, because the geological conditions of the area are not favorable. In the rain season the level of water table become high and the contamination of groundwater may occur.

The alternatives suggested in this paper can be adopted in many other cities in the same situation. The population has to exert some efforts to convince the government to fight against the problem. The best way to do so is through the environmental education.

REFERENCES
