DEZENTRALIZED WASTEWATER TREATMENT IN COASTAL TOURISTIC AREAS USING STANDARIZED MODULAR BIOLOGICAL FILTRATION

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ABSTRACT

The selection of appropriate wastewater treatment technology for coastal tourist areas is an important engineering challenge. The local situation in coastal tourist cities and villages is characterized by (1) important daily and seasonal fluctuations in hydraulic flow and pollution, (2) high annual temperature variations, (3) scarcity of building area and (4) high housing density. In the same time coastal zones have to meet stringent effluent limits all over the year and need simple and easy technologies to operate.

This article presents the innovative technology of standardized modular biofiltration SMBF as adapted solution for wastewater treatment in sensitive coastal touristic areas and demonstrates practical results of existing plants.

Keywords: *wastewater treatment, touristic areas, biofiltration*

1. INTRODUCTION

Tourism in Greece has been a key element of the economic activity in the country, and is one of the country's most important sectors. Greece has been a major tourist destination and attraction in Europe since antiquity, for its rich culture and history, which is reflected in large part by its 18 UNESCO World Heritage Sites, among the most in Europe and the world as well as for its long coastline, many islands, and beaches.

Greece attracted 26.5 million visitors in 2015 and 30 million visitors in 2016 making Greece one of the most visited countries in Europe and the world, and contributing 18% to the nation's Gross Domestic Product [1]. Its capital city Athens, as well as Santorini, Mykonos, Rhodes, Corfu, Crete and Chalkidiki are some of the country's major tourist destinations.

The monthly distribution of total number of nights spent at tourist accommodation establishments in Greece shows a main season from June to September up to about 350,000 nights per month (see Figure 1). This touristic activity results for numerous municipalities to an increase of wastewater production up to a factor above 5 to 10 times compared with low season.

Greece is governed by a Mediterranean climate. In summer, the max temperatures are in the range of 28°C. In winter, the min temperatures are about 10°C (see Figure 2). Beside the mentioned (1) hydraulic and pollution annual variations, (2) annual wastewater temperature variations also (3) high concentrated wastewater in summer has to be taken into account for the design of each wastewater treatment plant.

Nevertheless the special situation in terms of annual variations in wastewater quality and quantity, coastal zones has to meet stringent effluent limits all over the year and need simple and easy technologies to operate. Especially for decentralized small to medium wastewater treatment plants specialized trained operators are often not available. The applied waste water treatment technologies in these areas need to be adapted in terms of investment and operation costs. Treatment plants should be (1) easy to operate, (2) mostly automatic, (3) modular and flexible for different hydraulic and organic loads.

Figure 1. Monthly distribution of the total number of nights spent at tourist accommodation establishments in Greece [1]

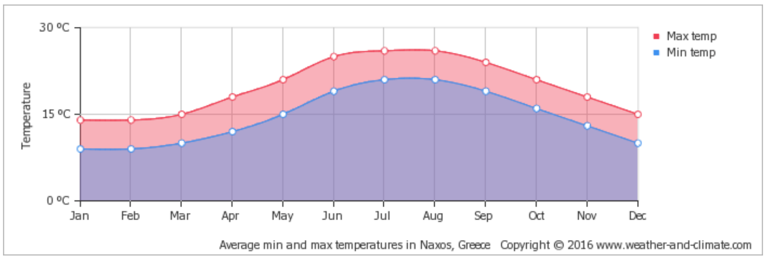

Figure 2. Monthly mean minimum and maximum temperatures over the year in Naxos, Greece - *Source:* www.weather-and-climate.com

2. STANDARDIZED MODULAR BIOFILTRATION SMBF

2.1. General aspects

The application of aerated upflow biofiltration in wastewater treatment goes back to the beginning of the 1980s when the first municipal biofiltration plants have been realized in the south coast of France. The basic concept of biofiltration is to achieve mechanical filtration and elimination of dissolved organic and inorganic pollutants, such as BOD and nitrogen (nitrification and denitrification) in one and the same reactor. The main advantages of biofiltration are (1) fully high grade water purification at different hydraulic and pollution loads and (2) independency of water temperature (high and low). Based on the long term positive results today more than 1.000 municipal wastewater biofiltration plants are in operation worldwide. In France about 50 municipal biofiltration plants in touristic areas are in operation since more than 20 years (see Figure 3).

The modern biofiltration technology today represents an economic, standardized aerated upflow filter in stainless steel filled with granular non floating media (burned clay 2-5 mm) (see Figure 4). The biomass is settling as biofilm on the filter material with specific surface of about 1.000 m^2/m^3. Each filter has a diameter of 3,40m with 7m height and is able to treat a pollution load of 3.000 PE including BOD removal, elimination of suspended solids, phosphorus elimination, nitrification and denitrification. The space requirement of a biofiltration treatment plant is only 25% compared with classical solutions. The SMBF is fully inside a building and is used for small to medium wastewater treatment plants in the range from 2.000 to 12.000 connected persons.

2.2. Presentation of SMBF technology

The principal function scheme of SMBF is portrayed in Figure 5. The wastewater is pre-treated by coarse and fine screen followed by primary settlement. In order to equalize hydraulic and concentration variations an equalization tank is implemented. After equalization the water is pumped into several independent units of aerated biofiltration tanks. Wastewater purification is affected through biological activity and mechanical filtration. The clean and filtered water with low concentrations of suspended solids of about 5-10 mg SS/L leaves the reactor at the top. A secondary clarifier is not necessary. For disinfection the waters are treated by UV. The generated sludge is lead into the aerobic sludge digester for stabilization. After stabilization the sludge is dewatered by centrifugation before to be trucked away. The total sludge production of the SMBF plant is about 10 to 20% lower than a classical solution [4]. Each biofilter is operated as independent unit and can be stopped or operated at any time and according to actual needs. In this manner an adapted operation of biofilter units during day and over the year is possible (see Figure 6). The function and operation of each filter is regulated automatically by the SCADA program according to continuously measured actual hydraulic load of the plant. In this manner low energy consumption and full results are achieved at any time of the year. The energy requirement of as SMBF plant is usually about 20% lower than a classical solution [2]. This energy saving is a result of (1) high oxygen exploitation inside the filter, (2) no need of air for mixing of sludge liqueur and (3) due to adapted operation of biofilter units according to actual load with standstill times of biofilter units.

Figure 3. Examples of main municipal touristic biofiltration plants in France [Aquabiotec]

Figure 4. Biofiltration tank serving 3.000 Population Equivalents [photo: Aquabiotec]

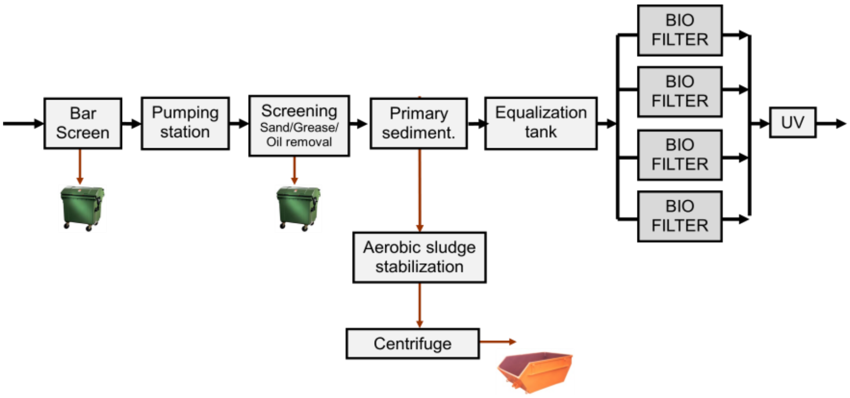

Figure 5. Treatment scheme SMBF plant serving 12.000 Population Equivalents

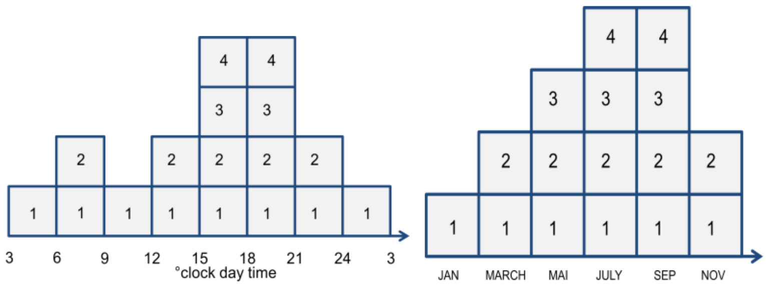

Figure 6. Operation of biofilter units in touristic site during day and year

2.3. Example of SMBF treatment plants

The SMBF has considerable savings in volume and space. For example, the space required for a municipal sewage plant can be cut down to 25% compared to required space for activated sludge or SBR plants. The low space requirement for SMBF plants makes a fully covered in-house treatment plant economically possible. As a fully indoor solution without noise or bad odour inconveniences the WWTP can be constructed close or even inside villages or towns and inside or close to tourist areas. The fully indoor solution protects the plant against impact of hot and cold climates and against unauthorized entrance. Based on the mentioned advantages of SMBF technology numerous plants have been realized in touristic areas and are in operation now since more than 15 years. Figure 7 shows a touristic SMBF in France with 5.000 PE connected persons. The architecture of the building is assimilated in the natural environment. No noise, no smell is caused by the plant and close neighbourhood is possible.

3 ENERGY DEMAND

The energy demand of biofiltration plants are mainly determined by the energy consumption of (1) biofiltration feeding pumps and (2) the process air blowers. The main difference to classical activated sludge plants is that (1) the necessary air input for biofiltration is only determined by the biological oxygen need for microbiological processes and not for (2) mixing of aeration tank. Especially during times of low loading (for ex. during night and low season) classical activated sludge plants need high air input only for mixing of tanks. As a result the energy consumption of biofiltration plans are about 20% to 30% lower than activated sludge plants (see Figure 8).

In the same time the operation of each biofiltration unit is adapted to real actual load. As a result the energy consumption of a modular biofiltration plant is a linear function of load. In case of a treatment plant designed for 10.000 PE at full load the energy consumption will be about 1,000 [kwh/day]. The same plant with 30% of load will need only 30% of energy resulting in about 300 [kwh/day].

Figure 7: Example of SMBF plant in touristic site serving 5.000 Population Equivalents [photo: Aquabiotec]

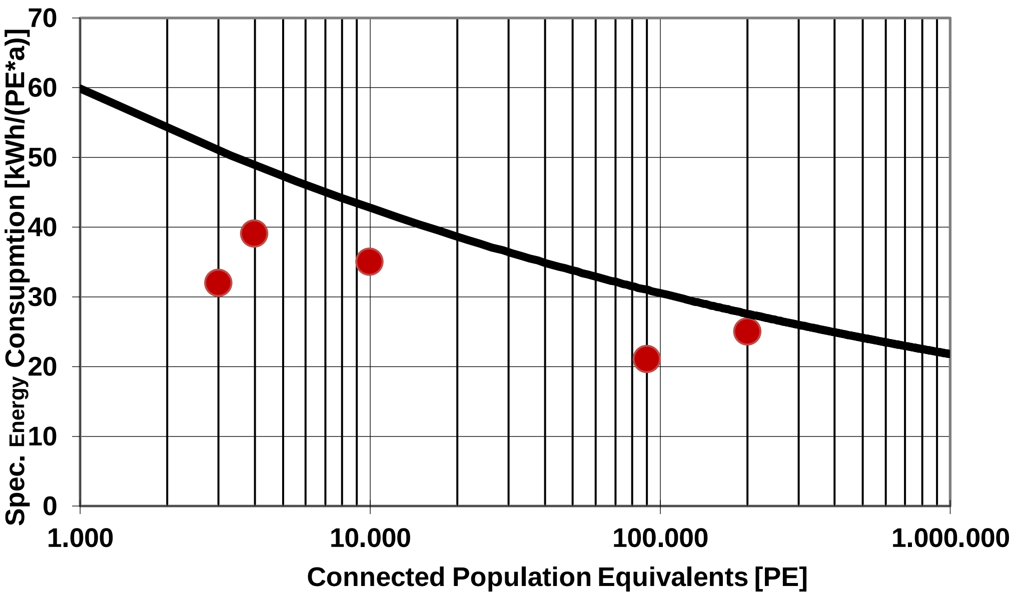

Figure 8: Specific energy demand [kwh/(PE*a)] of biofiltration plants (red points) and al treatment methods (black line) as a function of connected population equivalents PE

4 COD OUTLET CONCENTRATIONS

Whereas for activated sludge plants the biological efficiency depends mainly on the sludge age resp. on the BOD sludge load in terms of kg BOD/(kg DS.d), the COD outlet concentration of biofiltration plants mainly depend on the of the COD volumetric load of the biofilter material. Depending on the COD volumetric load between 0,5 and 10 kg COD/(m³.d) load the COD concentration of municipal wastewater treatment plants is in the range between 20 and 120 mg/l COD (see Figure 9).

5. RESULTS

The treatment results of a municipal touristic SMBF plant during one year of operation are demonstrated in Figures 10 and 11. The results show that at the inlet of plant high variations in terms of total N and BOD concentration can be observed. These high variations are usual for touristic sites due to (1) seasonal different population, (2) water consumption and (3) precipitation. Nevertheless the high variations at the inlet, stable outlet concentrations in terms of BOD and Total Ammonia Tot-N are achieved. The outlet concentration for BOD is usually below 10 to 15 mg BOD/L. The Tot-N concentrations at the outlet are usually below 5 to 10 mg N/l. COD outlet concentrations < 60 mg/l are achieved.

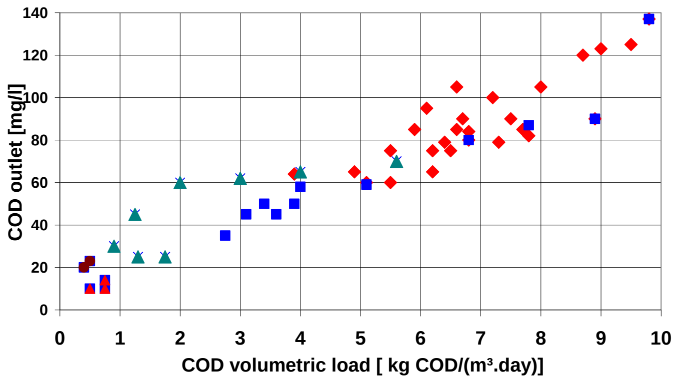

Figure 9: COD outlet concentration as a function of COD volumetric load SMBF

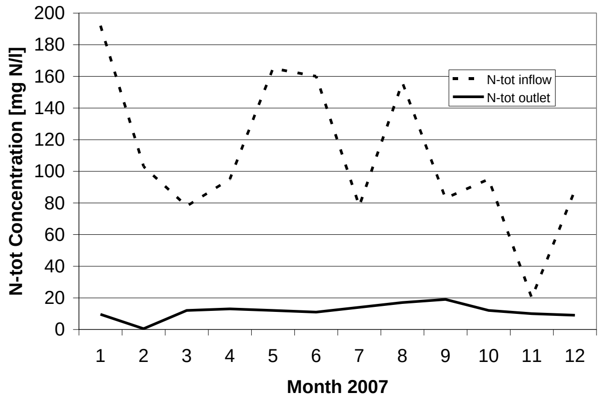

Figure 10: Tot-N in and outlet concentrations of municipal touristic SMBF WWTP

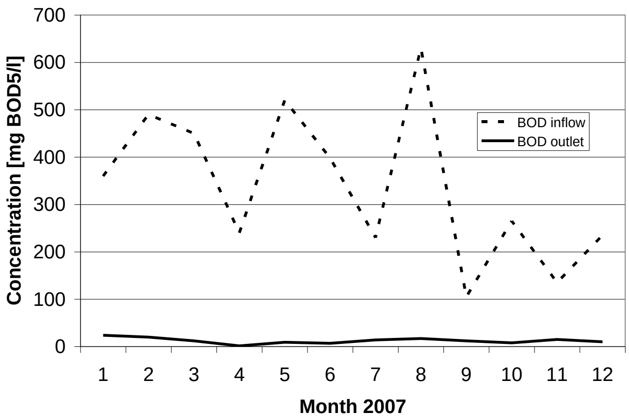

Figure 11: BOD in and outlet concentrations of municipal touristic SMBF WWTP

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