APPLYING THE MBR TECHNOLOGY IN WASTEWATER TREATMENT WITH REUSE OF WASTEWATER ON COASTAL AREAS IN CROATIA

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ABSTRACT

Water reuse is called the greatest challenge of the 21st century. It is the only solution to close the loop between water supply and wastewater disposal. In many parts of the world reclaimed water is used as a water resource.

The membrane bioreactor (MBR) provides a number of environmental benefits. The growing demand for clean and safe water is not only pushing users to limit the use of fresh water, but also to reuse wastewater. The MBR technology is a cost-effective, sustainable solution for new, efficient, advanced municipal wastewater treatment. Continuing development and adaptability of the MBR technology creates the opportunity for a widespread use in Croatia, particularly in the coastal areas and river banks which belong to the sensitive recipient zone.

The by-products of the membrane filtration, sludge and water, can be reused for different purposes, i.e. for watering green surfaces, or in case of the sludge, for fertilizing in agriculture

Water reuse is built upon three principles:
- providing reliable treatment of wastewater to meet strict water quality requirements foe the intended reuse application
- protecting public health
- gaining public acceptance

Water reuse application includes:
- agricultural irrigation
- tourism : golf and tennis course watering
- landscape watering including the irrigation of parks, playgrounds, green surfaces
- industrial activities for cooling, process needs
- non-potable uses: toilet flushing, fire protection, flushing of sanitary sewers

Keywords: MBR technology, reuse of wastewater, coastal areas, by-products

INTRODUCTION

In some parts of river/water districts, defined as protected areas on the basis of the National Water Protection Plan and the EU Water Framework directive, the need for special water protection measures is evident. Water pollution control and water protection in protected areas have priority in water resources planning and management. Water protection measures have to be carried out on the entire territory of Croatia, while there is justified need for additional stricter protection measures on the protected areas. Water protection in the protected areas is based on maintaining a specific water quality (of category I and II). More stringent water protection conditions refer particularly to the control of discharge of dangerous substances into the environment. The choice of the right wastewater treatment technologies is the most important thing in planning the water reuse system because they are the important way of decreasing or eliminating the environmental risk.

Under existing regulations, the protected areas in Croatia cover 28% of its total territory.

The selection of wastewater treatment system depends to a large extent on the level of protection of an area. As the level of protection increases, higher efficiency of treatment is required, which is why only those technologies are analyzed which provide the required efficiency without additional risks. Since the coastal areas and river banks belong to the very sensitive recipient zone, the MBR technology of wastewater treatment is the most suitable for such demanding locations.

Continuing development and adaptability of the MBR technology creates the opportunity for a widespread use in Croatia, so that its future application can be foreseen in protected areas, particularly those in sensitive and very sensitive areas.

The areas of special interest in terms of the MBR technology application in Croatia are the following:

- environmentally sensitive areas of national interest (national parks and nature parks)
- areas with drinking water shortages (islands, coastal areas)
- areas of “semi-closed” sea (estuaries, gulfs)
- areas with sensitive surface recipients
- tourist camping sites and hotel complexes
- bathing areas
- sanitary protection zones I and II

Phosphates and nitrogen, which cause algal bloom, are removed from water. The new plants occupy 1/3 less space than standard biological plants.

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A one-year test period for the wastewater treatment plant, MBR 500, was recently initiated at the camping sites Stupice on the Istrian Peninsula, to which approximately 70 households of the Premantura settlement are presently connected. The same type of plant is already in use at the Umag camping site, at a tourist resort near Rovinj, and in the Rovinj tobacco factory in Kanfanar. Since the coastal areas and river banks belong to the sensitive recipient zone, the MBR technology of wastewater treatment is the most suitable for such demanding locations.

As of now there are 5 such plants (MBR technology) in function in Istria, while about 10 new plants are planned in 2009.

Membrane bioreactor (MBR)

The MBR technology is a cost-effective, sustainable solution for new, efficient, advanced municipal wastewater treatment and belongs to a group of separation processes with biological treatment using activated sludge. The membrane technology provides a number of environmental benefits.

The application of MBR process in municipal wastewater treatment is very simple from a mechanical point of view and from the aspect of operating conditions, and is highly efficient. The basic benefit of applying the MBR technology lies in the fact that these are relatively small plants which at the level of applied technology have installed potential for tertiary wastewater treatment, with low output concentrations of suspended solids, COD, BOD5, ammonia, TN and TP (tertiary treatment). With the removal of nutrients, phosphorus and nitrogen, the main cause of the recipient's eutrophication is eliminated.

Table 1: The legally prescribed quality of treated water for discharge into class II recipient, and the quality of effluent water from an MBR plant

	Parameter	Concentrations permitted for discharge into water class II	MBR values*	Efficiency of MBR plant*
1	BOD_5, (mg O2/l)	< 25	< 2	95 ÷ 99%
2	COD (mg O2/l)	< 125	< 20	90 ÷ 96%
3	Suspended solids (mg/l)	< 35	< 2	97 ÷ 99%
4	Total P (mg/l)	< 1	< 0.5	87 ÷ 95%
5	Total N (mg/l)	< 21	< 15	85 ÷ 96%
6	Turbidity (NTU)	< 1	< 1	99.9%
7	Removal of bacteria	-	-	>99.99%

*This data is for information only and serves as presentation of general capacities of membrane technology for water treatment.

Waste sludge treatment

The amount of excess waste sludge generated is minimal, and the sludge is adequately and properly stabilised. This characteristic enables the application of waste biosludge treatment, e.g. coagulation. The excess sludge would normally amount to some 0.5 – 0.7 kg per 1 kg of BOD, depending on the temperature, sludge age, and the requirements relating to effluent quality. With MBR technology these quantities may be significantly reduced, which is why 0.1 – 0.3 kg/kg BOD can be expected.

RESULTS AND DISCUSSION

Example of water reuse: Camp Park Umag – Istria

Because of its quality, diverse offer and horticulturally rich landscaped appearance it has been described as a small nature park. It is the first camp in Croatia which has installed a MBR for wastewater and its implementation enables the reuse of wastewater thus ensuring protection of the local waters and the environment.

The Mediterranean region encompasses the coastal and insular area of Croatia, which stretches from Istria on the northwest to Konavle on the southeast, on which 31% of Croatia's population lives, Figure 1. The climate is of Mediterranean type, with a long sunny and warm period. Winters are mild, with temperatures which rarely drop below zero degrees Celsius. The further one goes from the NW to the SE, the annual temperature increases, and the amount of precipitation falls. Such climatic conditions are favourable for all wastewater treatment systems, particularly for those whose operation is based on biological processes.

Figure 1. Location of Camp Park Umag

MBR plant on this location was constructed in 2006. This is a seasonal settlement. A plant was put into operation at the end of May and it was in function until October.

The camp is equipped with some 5,500 accommodation units with ten toilet blocks, and a central reception office, accompanied by a shop and a restaurant-pizzeria. A freshwater pool with amenities is located in the central part of the camp. All the facilities within the camp are connected to internal sewerage. The internal sewerage system collects sanitary and technological wastewater from restaurant kitchens, treated previously on grease traps. Wastewater undergoes treatment in the camp's own MBR plant. The plant consists of a coarse screen, a fine sieve (0.5 mm), an equalization basin, a denitrification basin, and two membrane reactors (120 m^3). The excess of biological activated sludge is partly returned to the denitrification basin, and partly to a basin for aerobic stabilization of sludge (150 m^3) with aeration and coagulation. The treated sludge is briquetted and is used as fertilizer on the green areas within the camp. The treated wastewater is used for washing out toilet blocks and for watering the green areas within the camp; certain quantity of the treated wastewater overflows and is discharged through a submarine outfall.

The quantity of overflow wastewater treated in the MBR plant that is discharged into the sea can under normal operating conditions range between 0 and 40% of the quantity of water from the water pipeline. The remaining quantity of water from the water pipeline is used for supplying the pool with freshwater (ca. 7,000 m^3 per year), and water losses from internal water supply system account for up to 10%. The quantity of wastewater treated in the MBR plant that is needed for the watering of

green areas, depending on weather conditions and on the installed irrigation system and its further extension within the camp, ranges between 40% and 70% of water from the water pipeline. Certain quantity of water treated in the MBR plant recirculates within the toilet flushing system of toilet blocks.

Treated sewage water was analyzed and results are presented as average per year for period 2004-2007. (Table 2, Table 3 and Table 4)

Table 2: Analyses of wastewater for 2004, 2005, 2006 and 2007

c (mg/l)	BOD	COD	TN	TP
2004	373.3	633	98.9	10.2
2005	186.2	375.2	72.62	8.12
2006	13	52.5	13.25	0.64
2007	8	59.7	10.05	0.76

Table 3: Annual loads for 2004, 2005, 2006 and 2007

Load (t/y)	BOD	COD	TN	TP
2004	18.65	31.6	4.9	0.51
2005	12.2	24.6	4.7	0.53
2006	0.45	1.84	0.46	0.0227
2007	0.63	4.71	0.79	0.06

Table 4: Discharged waste water amounts in 2004, 2005, 2006 and 2007

Q (m^3/y)	Discharged	Recirculated
2004	49957	0
2005	65507	0
2006	70373	40 -70% (water permit)
2007	78967	40 -70% (water permit)

Waste sludge treatment

The sludge that settled during wastewater treatment can be used in agriculture as fertilizer, following the composting process which is currently carried out at the Faculty of Agriculture in Zagreb and the subsequent analyses of the results.

One of the preconditions for the application of sludge in agricultural production of field crops is a chemical analysis of the agricultural land on which sludge would be applied, as well as the analysis of the sludge itself. Every year an authorized laboratory performs laboratory analysis of sludge, verifying its exceptional quality and the

justification of its application in agricultural production, thus closing the substance circulation cycle in nature.

Bionutritive value viewed in terms of analytical data of macrobiogenic elements points to a rich supply of the analysed material with nitrogen, phosphorus, and potassium, which can be brought into correlation with potential supplementation of materials rich in these elements.

- N (total per dry weight) = 6.81 %;
- P_2O_5 (total per dry weight) = 5.40 %;
- K_2O (total per dry weight) = 4.30 %).

Since the analysed material is rich in organic matter (68%), and since it is richly supplied with basic biogenic elements (NPP), it can be applied in agricultural production for raising the level of organic matter, as well as in the nutrition of certain plant species.

The concentration of heavy metals in the analysed sample is below maximum allowed concentration laid down by the Regulation on the protection of agricultural land against pollution from dangerous substances (OG No. 15/92 dated 25 March 1992).

The quantity of material applied on crop-farming areas, meadows, and lowland pastures whose soils contain none of the heavy metals has to be 50% lower than the limit value (Table, Article 3 of the above-mentioned Regulation). The applied quantity also depends on the share of dry weight, which is why the maximum quantity of applied sludge should not exceed 10 tonnes of dry weight per hectare.

The analysed material meets the minimal conditions for potential application for agricultural purposes as soil improver, because it will contribute to the improvement of physical and/or chemical characteristics of the soil. Furthermore, the analysed sludge might also be applied as one of the components in the production of cultivation substrates.

CONCLUSIONS

Over the last few decades, the potential for reclaiming water from wastewater instead of disposal to the environment has been recognized. In many parts of the world, it is not possible for water to be used only once.

Water reclamation and reuse make the best use of existing water resources by:

- conserving high quality water supplies by substituting recycled water for applications that do not require that quality,
- protecting aquatic eco-system by reducing the quantity of nutrients.

In many parts of the world, agricultural irrigation using reclaimed water has been practiced for many centuries. Landscape irrigation, such as irrigation of golf courses, parks and playgrounds has been successfully implemented in many urban areas.

The reuse of waste water offers many attractive benefits, including reduced pollution of water sources and reduced application of fertilizers.

Water reclamation is the new challenge in the new millennium. Wastewater is a valuable water and nutrient resource and too valuable to waste. More and more people need to benefit from our decreasing clean water resources. It is important that technologies are developed to reclaim water for an acceptable price with minimising risks for human health.

The concept of the membrane bioreactor is getting increasing attention. Membrane technology can play an important role in water reclamation schemes. Its costs are decreasing and its benefits are increasing.

This field is of interest not only for water-stressed areas but also for a country rich in water such as Croatia. Large parts of Croatian territory are proclaimed as sensitive and require specific measures to be taken with regard to water supply and wastewater treatment. Therefore, some improved and new technologies of wastewater treatment would be needed in Croatia in the future. The MBR technology is suitable for such kinds of applications, because it offers high treatment efficiency and has comparably low space requirements. MBR technology also enables the direct reuse of treated wastewater without additional disinfection especially for agricultural purposes.

Ecology and tourism go hand in hand, and this topic is very important in the Mediterranean countries.

At the end, let us quote the importance of The Bellagio Framework 2004 for MBR Technology:
“Population growth, rapid urbanization, and finite water resources lead to human misery, including catastrophes that can affect all of humankind. Today, water management responds too slowly to needs and is unsustainable; water institutions are falling further behind, not making gains toward water sustainability. Due to plummeting costs and dramatically improving performance, water-treatment applications based on membranes are blossoming. In particular, Membrane Bioreactors (MBRs) are today robust, simple to operate, and ever more affordable. They take up little space, need modest technical support, and can remove many contaminants in one step. These advantages make it practical, for the first time, to protect public health and safely reuse water for non-potable uses. Membranes also can be a component of a multi-barrier approach to supplement potable water resources. Finally, decentralization, which overcomes some of the sustainability limits of centralized systems, becomes more feasible with membrane treatment. Because membrane processes make sanitation, reuse, and decentralization possible, water sustainability can become an achievable goal for the developed and developing worlds.

Attaining water sustainability will require commitment and a holistic approach from policy makers, planners, funding agencies, educators, implementing agencies, and technology providers - all those concerned with economic, environmental, technical, and social/cultural aspects of development. The need is urgent, but an enabling technology for preventing unnecessary human misery and achieving water sustainability is ready. The Bellagio International Residency Team recommends that all the stakeholders accelerate the development and use of membrane technology.

As we noted in our Bellagio Framework on MBR Technology, attaining water sustainability will require commitment from policy makers, planners, funding agencies, educators, implementing agencies, and technology providers. The need is urgent. MBRs can help achieve water sustainability and prevent unnecessary human misery."

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