Evaluation of wastewater systems in rural areas of the Balkan region with focus on ecological and socio-economic aspects

Wastewater is usually generated from the kitchens and toilets of residential households, the effluent from small and large industries, residues and diluted pharmaceutical drugs from hospitals, and generally from public institutions in rural and urban settlements. Over the last two decades, the treatment, reuse and methods of emission of wastewater into surrounding ecosystems have become a topic for scientific research and technological development with regards to environmental protection and sustainability. Hence the operation and maintenance (O&M) of waste-water treatment plants (WWTPs) should be economically viable (affordable), socially acceptable, technically and institutionally appropriate, manageable and adaptable, with an aim to protecting the environment and all the natural resources therein (SuSanA, 2008). This paper puts forward the outcomes of a development cooperation project which aimed to evaluate WWTPs in rural areas in the Former Yugoslav Republic of Macedonia (FYROM).

FYROM has one of the lowest per capita gross domestic products (GDPs) in the whole of Europe, and the country is highly dependent on external financial loans and grants for development. The rural areas of FYROM are generally characterized by low income populations engaged mainly in the cultivation of fruit and vegetables and processing of diary products for local and regional markets, generating 11-12% of the country's GDP. Geographically, FYROM is a landlocked country characterized with dispersed and condensed cities, towns and villages with hilly/mountainous topography. The types and quality of residential units vary considerably from modern architectural styles in major urban cities to traditional architecture in rural areas.

The main goal of the project initiated by the Austrian Development Agency was to develop an approach for implementing appropriate wastewater technologies in rural areas of FYROM, as a pilot project for the Balkan region, based on the performance rating of existing systems (WWTPs). Analysis by Prandtstetten (2009) showed that problems associated with a lack of sufficient financial capital for the O&M of WWTPs in FYROM is similar to other developing countries like Albania and Romania, considering for example the percentages of rural houses that are connected to a sewer system and the ratio between wastewater disposal tariffs and average net income of rural population (Table 1).

This project focused on the ecological and socio-economical aspects of wastewater systems in FYROM with regards to affordability, investment costs and operational costs. The evaluation of the four treatment plants selected focused on the tariff structure (billing and methods of payments) as well as on the efficiency of the WWTPs.

The study was based on predefined objectives according to the European Standard for drainage and sewer systems outside buildings (EN 752, 2008). The four overall objectives of EN 752 are: Public health and safety; Occupational health and safety; Environmental protection; and Sustainable development.

Methods

The project team was made up of academic staff and lecturers from two partnering Universities[1] that included

This paper puts forward the outcomes of a development cooperation project that aimed to evaluate wastewater systems (treatment plants) in rural areas of the Former Yugoslav Republic of Macedonia (FYROM). Focusing on the lessons learned could be essential for the planning and operation of wastewater treatment plants (WWTPs) in developing countries with similar socio-economic and political characteristics to FYROM, for example Albania and Romania in the Balkan region. Four types of treatment plants were evaluated in four rural communities, each having sufficient treatment potential according to the European Union (EU) Urban Waste Water Directive (UWWD, 1991) in terms of chemical oxygen demand (COD), biological oxygen demand (BOD), and nitrogen and phosphorus removal. The outcomes of the survey showed that insufficient financial capital led to problems of operation and maintenance (O&M) (e.g. costs of repair and replacement of worn-out parts, and biological and chemical analyses). Due to the economic situation of residents in rural areas of FYROM, the wastewater tariff should be as low as possible. This low tariff structure is a fundamental selection criterion for choosing the most appropriate technology. Owing to this fact, the investment costs, the O&M costs as well as the energy consumption of the WWTPs selected for this evaluation should be as low as possible, but also have to be included in the tariff calculation. Beside the limited financial capacity of local residents, generating revenues from wastewater disposal tariffs poses a financial challenge to municipal authorities as only around 20% pay their disposal tariffs, thus the total operational costs of treatment plants cannot be covered. Municipal authorities need effective tools to improve tariff collection. Public acceptance and awareness of environmental and health issues have to be taken into account when considering the design and planning of WWTPs. The participation of stakeholders from the public and private sectors is of vital importance to the design and planning processes of WWTPs as the stakeholders' role would lead to the formulation of policies backed by good action plans and implementation strategies of wastewater management in FYROM and in other developing countries in the Balkan region. Water pollution control measures should also be planned particularly with regards to nutrient aspects. In rural areas alternative sanitation systems with nutrient recovery may be considered. In FYROM, there is lack of information on the environmental impact of wastewater management. The monitoring of surface and groundwater quality is strongly needed to fulfil the requirements of the FYROM National Water Act of July 2008, within which the principles of the EU Water Framework Directive have been implemented. By Thomas Ertl, Michael Wippel, Christoph Prandtstetten, Stefan Kuvendzijev, Helmut Jung, Norbert Weissenbacher, Florian Kretschmer and Todor Anovski.

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supervisors and master students, and one external supervisor. The project was begun in July 2008 after a two-day seminar at the University of Skopje. The project started with a research review regarding sustainable wastewater management (Ujang and Henze, 2006) and a baseline study on the socio-economic conditions of people living in rural areas of FYROM, in relation to wastewater generation, disposal and treatment. To achieve its objectives the survey employed face-to-face interviews as a technique to acquire relevant qualitative data. Ordinary face-to-face interviews were carried with local residents and their community heads, while expert face-to-face interviews (Rietbergen-McCracken and Narayan, 1998) were conducted with major political stakeholders, directors and operating personnel in four rural areas with WWTPs. Site monitoring and control of the four WWTPs was also carried out to gather technical/quantitative data needed for performance benchmarking.

A planning method was employed to strategically evaluate and identify the strengths, weaknesses, opportunities and threats (SWOT) of wastewater management in FYROM. Using the planning method (SWOT), analyses were carried out by all major participating stakeholders during a one-day workshop organized in Skopje, FYROM in August 2008. The outcomes of the workshop added value to the final analyses of acquired data and also to the final report writing. Four WWTPs consisting of two intensive (activated sludge and trickling filter systems) and two extensive (constructed wetlands

and aerated lagoons) processes of wastewater treatment financed by the Austrian Development Agency (ADA, 2008a and 2008b) were selected for monitoring, control and evaluation of the overall performance of the treatment plants.

These WWTPs are located in four rural areas[2] of FYROM and they include:

- Makedonski Brod – has an activated sludge system of wastewater treatment with 5000 PE (population equivalent). The treatment plant has been in operation since 2001.
- Krivogastani – has aerated lagoons with 4000 PE and has been in operation since summer of 2007.
- Cucer Sandevo – has a trickling filter system with 3000 PE and has been in operation since summer of 2009.

Country	Water	Wastewater	Tariff / average net income
Albania	20%	5%	-
FYROM	27%	10%	3.4%
Romania	17%	10%	2.6%
Austria	88%	83%	1.2%

Table 1
Connection rates in rural areas and tariff ratio (Prandstetten, 2009)

- Jasenovo – has a constructed wetland with 250 PE and has been in operation since autumn of 2006. Due to its geographical location the Jasenovo constructed wetland was specifically designed and constructed for the Jasenovo specialist hospital, which produces wastewater constituents of diluted pharmaceutical drugs used for the treatment of patients with lung infections and other cancerous illnesses.

Beside the collection of relevant quantitative and quantitative data, the sampling and analyses of inflow and outflow from each of the WWTPs was carried out under the supervision of the Vodovod i Kanalisazija laboratory[3] and the Austrian University laboratory. For the purpose of establishing a standard evaluation of all the WWTPs with regards to their adjoining rural population, a socio-economic/environmental assessment of the settlements in the entire catchment area was carried out. The final analyses of all quantitative and qualitative data gathered, employed the IWA's performance indicator/ evaluation system used for wastewater services (MATOS et al., 2003).

Results and discussion

Economics

The evaluation of the economical situation of FYROM showed that the average income of the total population is €258 ($351) per month (State Statistical Office, 2008). Due to a lack of statistical data it was difficult to obtain specific information concerning the economic situation of all the rural areas in FYROM. However, during the face-to-face interview phase conducted with local residents, it was gathered that the average income level of rural inhabitants is significantly lower (approximately €150 ($204)/month) than the income level of major urban cities. The average unemployment rate in FYROM is 34.8% (State Statistical Office, 2008). The unemployment rate in FYROM is one of the highest in the Balkan region and is expected to increase due to the global financial crisis, with the majority of unemployed people living in rural areas where agriculture is predominant (World Bank, 2010).

Operation and monitoring

As a criterion under the European Water Framework Directive (WFD), the management and operation should be such that treatment plants are financially capable of covering all operational costs with regards to replacements of broken/failed parts and population increase and settlement expansion. However, the outcomes of monitoring and control of the Makedonski Brod, Krivigastani and Cucer Sandevo WWTPs, excluding Jasenovo, showed that the standards of operations and maintenance of each of these plants fell short, for example not carrying out regular chemical analysis of the in- and outflow.

As put forward by UNEP (United Nations Environment Programme) (1997, cited by Muga and Mihelcic, 2007) the operational costs of conventional WWTPs (activated sludge and trickling filters systems) are on average much higher than the operational cost of the alternative WWTPs (constructed wetlands and aerated lagoons). The operational cost, total re-investment cost, running costs and energy costs of the four evaluated plants are summarized in Table 2.

Makedonski Brod's activated sludge treatment plant was designed to achieve maximum rate of efficiency in treating wastewater hence, its total operational cost was quite low when compared with the operational cost of Krivogastani's aerated lagoons used for treating wastewater.

The total operational cost of Jasenovo's constructed wetlands is almost zero as all other cost is included in the budgeted operational cost of the Jasenovo specialist hospital. The almost zero operational cost, of which most constructed wetlands offer, would tend to suggest that constructed wetlands have the lowest operational cost when compared with other types of WWTPs. Many years of worldwide experience with constructed wetlands have demonstrated that constructed wetlands used for wastewater treatment is a good option for settlements with less than 500 PE (e.g. Haberl et al., 2003; Cooper, 2009; Vymazal and Kropfelova, 2009). The high operational cost excluding total re-investment cost of Cucer Sandevo (trickling filter) is mainly due to the high cost of chemicals used for phosphorus removal.

Tariff collection

Due to the economic situation in rural areas in FYROM it was important to take the economic and financial capacities of the evaluated rural communities into consideration. The system and structure of wastewater disposal tariff showed that 80% of the local residents (except Jasenovo) connected via sewer system to the WWTPs are not paying the fees for the disposal and treatment of their generated wastewater ('bad payments'). Knowing the exact income earned by local residents was a difficult task to achieve, thus it was impossible for the survey to distinguish low income earner from high income earner. This lack of knowledge posed a limitation to predicting the willingness of local residents to pay for the tariffs for disposal of their generated wastewater.

Not knowing the income earnings of local residents and their willingness to pay for wastewater disposal poses a big issue for authorities to implement a legislative framework that allows appropriate measures to reduce 'bad payments'. At the time this survey was carried out, the reinvestment costs (amortization) were not fully included in the tariff system, which may pose huge financial and operational problems in the future. Should the operating parts or sensitive components which make up a WWTP fail to function at the expected standard, there exists the possibility that municipal authorities with a non-effective tariff system would lack the sufficient financial capital for O&M of their treatment plants (reinvestment cost). When municipal authorities lack the funds, there is the tendency to seek financial support from external donors, thus suggesting that the municipalities lack the ability to manage the operation of

the treatment plants on their own.

In situations when the O&M are not timely backed up by sufficient financial capital, delayed reinvestments might become very high due to inflation, which in turn would increase the tariff for wastewater disposal. When municipal authorities are faced with high costs to sustain the O&M of the treatment plants, there exists the possibility that municipal authorities will invest in the cheapest available technologies (bad investments), rather than investing on the best available technologies (BATs) that could stand the test of time and cope with increasing populations.

Wastewater treatment performance and environmental impact

The activated sludge system in Makedonski Brod, the aerated lagoons of Krivogastani and the constructed wetlands of Jasenovo fulfil the quality standards regarding treatment efficiency in water sensitive areas, i.e. 70-80% of nutrient removal or outflow concentrations of phosphorus (< 2mg/l) and of nitrogen (<15 mg/l) (EU UWWD, 1991). At the time of data collection the trickling filter of Cucer Sandevo was in the incubation phase. However, the WWTP was confirmed to be working properly by the plant operators. The performance evaluations showed that the wastewater treatment systems of Makedonski Brod, Krivogastani and Jasenovo are performing well. Although problems in financing new technical parts or components and chemicals for the laboratory analyses were evident, the O&M of the treatment plants were carried out in an adequate way. This was mainly because of the enthusiasm of the operators and improvisation when problems arose. Other factors which contributed to the performance rate of the treatment plants were the standard training and translated manuals given to the operating personnel before the plants began operation, and continuous supervision by Austrian sanitary engineers after treatment began.

The documentation of plant operations regarding chemical and microbiological analyses for self-monitoring of the WWTPs is normally carried out by the plant operators (internal supervision). In general, the results over the last few years showed that the WWTPs Makedonski Brod, Krivogastani and Cucer Sandevo have been working properly since they have been in operation. There was no data available for Jasenovo as no wastewater analyses have been carried out since the start of its operation in autumn of 2006.

Under the context of cost-benefit analysis the environmental costs on land, plants/animals, surface and groundwater resources of discharging domestic and industrial wastewater directly into the adjoining ecosystems, and the benefits of WWTPs to the rural communities have not been evaluated at the time of this survey. Hence, the importance of water quality was not taken into consideration during the design/planning phase of the WWTPs.

The principles of the European Union Urban Wastewater Directive (EU UWWD, 1991) and the WFD (2000) had been already implemented into the National Water Act, in July 2008. For the technical implementation of wastewater management strategies/procedures, Zessner et al. (2004) (see also daNUbs, 2005) put forward the following outcomes of a study regarding nutrient removal and recovery by WWTPs for the Danube River Basin. The study outcomes can be summarized in the following context. The management and treatment of wastewater by treatment plants have to conform strictly to the EU UWWD standards regarding the treatment and removal of nutrients (nitrogen and phosphorus). When these standards are not fully met by these conventional methods (intensive) due to other technical/financial reasons, alternative (extensive) methods of wastewater treatment have to be employed to deal with nutrient recovery. In the eastern Danubian countries only 50% of the population (residential houses and small/large scale industries) are connected to sewer systems, which suggests that nutrient management and its resulting impact on society and the environment have been given a low priority, therefore not conforming to environmental sustainability principles and the protection of natural resources.

When focusing on the appropriateness of wastewater treatment by plants in rural areas of FYROM, the water quality of the receiving rivers, lakes and streams must be of high priority and thus it must be taken into consideration. This requires the implementation of an adequate monitoring system. As mentioned before there is a lack of environmental data. Nevertheless data is needed to define the ecological status of rivers and lakes. A monitoring system allows the investigation of point sources of pollution, which would provide a good scientific basis for the implementation of integrated nutrient management for river basins. Allan et al. (2006a) presented reasonable and functional ideas for strategic river basin monitoring in regards to the WFD. A 'toolbox' for biological and chemical monitoring requirements was reviewed by Allan et al. (2006b). Halasza et al. (2006) described the establishment of a surveillance monitoring system for small water catchment areas, and Borja et al. (2005) has provided a methodological approach to assess the risk of failing to achieve good ecological status according to the EU WFD.

SWOT and stakeholder analysis

The SWOT stakeholder analyses that were carried out at the workshops in Skopje showed that the major stakeholders were aware of strengths, opportunities, weaknesses and threats with regard to wastewater management. The outcomes of the SWOT analyses put forward that the threats and weakness which the treatment plants may face could include insufficient financial capital to sustain the operations of the treatment plants, hence it would require a transparent tariff system coupled with raising the awareness level of local residents. The aforementioned criteria are necessary because local residents' participation and their willingness to pay tariffs are essential to the sustainability of treatment plants through revenue generation (re-investment financial capitals) in cases where the re-investment financial capital is given by external donors. The

	Makedonski Brod activated sludge	Krivogastani lagoons	Cucer Sandevo trickling filter [1]
Total operational costs incl. re-investment per PE	€18.20 ($25)/(PE.a)	€24.90 ($33.70) /(PE.a)	€11.70 ($15.80)/(PE.a)
Total operational costs excl. re-investment per PE (PE.a)	€4.40 ($6)/(PE.a)	€5.40 ($7.30)/(PE.a)	€8.40 ($11.40)/(PE.a)
Total re-investment costs per PE	€13.90 (18.80)/(PE.a)	€19.50 ($26.40)/(PE.a)	€3.20 ($4.30)/(PE.a)
Total running costs per PE	€1.20 ($1.60) /(PE.a)	€3.20 ($4.30)/(PE.a)	€6.90 ($9.30)/(PE.a)
Energy costs per PE	€1.00 ($1.35)/(PE.a)	€2.90 ($3.90)/(PE.a)	€2.90 ($3.90)/(PE.a)

[1] Calculated with 0.5% of the investment costs (construction works of WWTP & sewage system) per year (with 4% for the WWTP and 2% for the sewage system in Mak. Brod & Krivogastani)

Table 2
Comparison of the operational costs (inclusive and exclusive the re-investment costs), the total re-investment, running and energy costs per population equivalent

lack of local residents' participation (bottom-up strategy) in the treatment of wastewater could mean that the O&M of treatment plants are destined to fail (SuSanA, 2008).

Analyzing the opportunities and strengths using the SWOT method, the major stakeholders could identify opportunities since it was (then) a new technological/environmental approach to managing wastewater in FYROM. With this new approach jobs could be created for individuals who may have acquired training/education; the end-products (dewatered/treated sludge) could be packaged by municipal authorities and then sold to rural farmers for application on land, thus serving two purposes: generating revenue for the management of the treatment plants and meeting the economic goals of both the rural farmers and municipal authorities.

In the same vein, highlighting the strengths while using the SWOT method, stakeholders could identify possibilities where municipal authorities involved in wastewater management could learn from past mistakes by capitalizing on the knowledge of how projects (of this magnitude) failed in the past, and how they could utilize the expertise of external development partners through knowledge and information sharing. Using this strategic method to approach planning and operations by municipal authorities in FYROM the whole process could lead to establishing a more sustainable partnership and trust between FYROM as a country and its development partners.

Some key opportunities highlighted by the stakeholders while using the SWOT method that that the management of WWTPs in conjunction with development partners would lead to were:

- Improvement of water quality of receiving rivers and lakes.
- Knowledge transfer, information sharing and network establishment based on trust and mutual working relationships.
- Technical implementation of river basin management/strategies.
- Satisfying the objectives of EN 752 by achieving public and occupational health and safety, environmental protection and sustainable development.
- Creation of new jobs, which would lead to economic growth and development and improvement of the economy.
- Stimulate public participation in environmental protection issues and thus raise the awareness level of local residents.
- Operators of treatment plants attaining high competences and expertise would set standards of wastewater management for other countries in the Balkan region.

Furthermore, the stakeholders could also use the SWOT planning method in highlighting threats which must be treated with high priority. They included the following:

- The national rate of poverty (high) and rural income earnings (low) coupled with little or no environ mental protection awareness could lead to the non-participation of local residents in the wastewater management process.
- Local residents' unwillingness to pay wastewater disposal tariffs may pose difficulties in generating revenue needed to cover the operational costs of treatment plants, hence hindering their performance.
- Lack of information and technical knowledge may pose a challenge for treatment plants aiming to achieve high rates of performance/efficiency.

Conclusions

This study revealed the following key aspects that need to be considered for sustainable management and development of WWTPs in rural areas of FYROM. The strategies developed and implemented, the challenges faced and resolved, and the whole project management cycle could be used as a model for similar projects in developing countries in the Balkan region, and elsewhere in the world with similar socio-economic and environmental realities.

Economic situation and public participation/acceptance

According to the economic situation of most people living in rural areas of FYROM the wastewater disposal tariff should be as low as possible. However at their current levels this cannot cover all O&M costs. Therefore, the options left for the generation of revenues to cover the investment and O&M costs are either pegging the wastewater disposal tariffs (exponential discounting) or seeking grants/loans from external donors. Alternative wastewater treatment systems such as constructed wetlands have low O&M costs and low or zero energy consumption, so may therefore be considered as appropriate alternatives.

Another challenge which the economic situation poses to the effective management of WWTPs in FYROM is the willingness of local residence to pay wastewater disposal tariffs. Only 20% of the total population connected to the treatment plants in the Makedonski Brod, Krivogastani and Cucer Sandevo communities pay their disposal tariffs. This therefore suggests that the lack of willingness to pay by local residents displays a low level of environmental awareness and motivation and the resulting consequences. What is therefore needed by the municipal authorities is an effective method of tariff collection backed by enforcing laws and policies. Thus, in the design/planning process of wastewater treatment systems, local residents' participation should be given high priority to create the acceptance needed to generate revenues to cover operational costs.

Education and training

Training programmes for potential operators are essential for the proper O&M of the wastewater treatment systems and the survey showed that most operators reported sufficient training on O&M. Nevertheless, there is need for further development of plant operator knowledge, expertise, commitment and capacity, which are necessary for high performance and good outputs of treatment plants. These are fundamental to sustainable management of WWTPs in the long term. Furthermore, external control of system performance should be institutionalized as this survey showed that there exists a lack of continuous independent monitoring of the evaluated treatment plants.

Treatment performance and environmental impact

The evaluation showed that all treatment technologies fulfil the EU UWWD standard for sensitive areas, which includes nutrient removal. As cost is a crucial factor for consideration, there are cheaper technologies without nutrient removal that would fulfil the basic requirements for non-sensitive areas. To define the ecological status of water bodies according to the EU WFD (2000), quality monitoring is strongly needed since there is a lack of information on environmental conditions and the impact of wastewater management in FYROM. Impact assessment on receiving rivers/lakes should therefore be integrated into regional and local planning procedures. It is imperative to know at the design/planning phase which appropriate wastewater system would suit the municipal/rural economic realities, considering the operational costs. Furthermore, the objectives of wastewater treatment systems should clearly stated on whether the goal is to improve public/occupational health, environmental protection/

development, or both.

Organizational aspects

The lessons learnt in development cooperation in south-eastern European countries in the concerning wastewater management as put forward by Prandtstetten (2008) can be summarized into two categories:

Donor coordination and cooperation (harmonization) and alignment with national partners

As stated above, the EU WFD approach of river basin management has been implemented into the FYROM National Water Law. For this large scale approach it is necessary to cooperate with other donors aligned with national institutional and legal settings so as to obtain the necessary financial capital needed for interventions at this level. Because Austria through its department for international development and co-operation (ADC) has been working on development issues such as this in the Balkan region for a long time, there is wealth of experience gathered which was utilized in their interaction with administrative authorities in the region. These actions led to Austria attaining a coordinating and mandatory role as an 'honest arbitrator' to which other development donors are being invited and integrated into the processes.

Capacity building, institutional strengthening (on different levels)

The cooperation between the University of Natural Resources and Applied Life Sciences, Austria and the University St. Kyril and Methodius (UKMS), FYROM was the basis for this project and reveals the role of universities in sustainable infrastructure development. Universities can play an important role in the education of engineers for training of sewer personnel, research in construction, O&M and rehabilitation. The Austrian Development Corporation (ADC) aspires to boost scientific cooperation and knowledge transfers between the region and Austrian academic institutions in the long term. ●

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Notes

[1] University of Natural Resources and Applied Life Sciences (BOKU) Vienna and University St. Kyril and Methodius (UKMS) Skopje.

[2] There are various definition of 'rural areas', in the context of this work settlements up to 5000 inhabitants with predominant agricultural economy are considered as rural

[3] The Vodovod I Kanalisazija laboratory is part of the Skopje Public Water Utility, equipped with 'state of the art' drinking water and wastewater analyzing equipment.