Waste Water Treatment Facilities as Potential Resource of Phosphorus

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Abstract

Phosphorus is a resource and a pollutant. Waste water contains significant amount which needs to be removed in order to prevent pollution of the environment. Depending on the degree of treatment, along with the sewage sludge, phosphorus can be recovered. The aim of this paper is to give preliminary information on quantity and management of phosphorus in waste water in Serbia, with a focus on the evaluation of the phosphorus resource potential.

Keywords: Waste water, Material and substance flow analysis, Phosphorous

1. Introduction

In a transition country such as Serbia, management of phosphorus is focused on controlling of phosphorus emissions in surface and underground water [1]. While phosphorus is a non-renewable, essential resource with no substitute, and mainly obtained from phosphate rock, other alternative phosphorus sources are available. As significant amounts phosphorus can be found in the biomass, it should be considered phosphorus utilization of from biodegradable waste streams. Available techniques for recovering and reusing phosphorus can range from low-tech, small-scale solutions like direct reuse, through to large scale, high-tech solutions such as recovery from wastewater treatment plants [2].

Phosphorus recovery from wastewater has received the most attention. There are several appropriate processes for recovery and reuse: source separation and reuse of excreta; direct use of wastewater; use of sewage sludge; struvite generation and reuse; incineration and reuse [2].

Sewage sludge has been widely used as a supplement to agricultural soils because it provides a valuable source of plant nutrients and organic matter theory and principle [8, 12], and this become more important from other options for the disposal of sewage. But sewage sludge also contains substances that could be harmful to plants and soil and therefore the use of sludge in agriculture is regulated to minimize potential environmental problems [11]. According to Eurostat, in 2010 in Europe, 42% of municipal sewage sludge was treated and used on farmland, 27% was incinerated, 14% was disposed of by land filling and 17% was disposed of in other ways.

Currently in Serbia, there is no sufficient number of waste water treatments plants in which phosphorus can be extracted within sewage sludge. Extraction level depends on the level of treatment. Annually amount of sewage sludge is small, but in the future we expect an increase in their number so this waste stream must be taken into account. In Serbia, only 5-10% of total generated waste water is treated [3], which results with 50,000 tons of sewage sludge usually disposed on landfills [4].

2. Materials and Methods

In order to estimate the phosphorus as potential resource the following steps are conducted:

1. Analyzing of current wastewater management practices in Serbia.
2. Estimation of emitted phosphorus in wastewater amount.
3. Analyzing of potential phosphorus in wastewater.

In Serbia significant environmental pollution occurs due to non-collection of municipal waste water. Around 30% of the population is not connected to the sewage network. Only small part of the collected waste water was treated. The most common is primary and secondary treatment, during which the small amount of phosphorus can be recover, as shown in Table 1.

Table 1. Percentage of reduction depending upon the treatment

Treatment level	P recover, %
No treatment	0
Primary treatment	10
Secondary treatment	30
Tertiary treatment	90

Waste water contains a certain country specific amount of phosphorous. According to Danube River Basin District Management Plan – Update 2015, country specific emission coefficient for Serbia is estimated at 1.8 g P per population equivalent (PE) per day [5].
In order to show the flow of phosphorus and its potential for recovery, methodology based on the Material flow analysis (MFA) and Substance Flow Analysis (SFA) is used [6]. This is useful methodology for modeling any material based system [7]. For modeling scenarios, the software STAN has been applied [8].

3. Results and Discussions

The status quo of phosphorus flows in waste water is presented in Fig.1 Calculations are based on PE emission, sewage network system and types and amount of treatment.
As a potential resource of phosphorus, sewage sludge separated from the waste water can be used. It can be concluded that only 4% phosphorus can potentially be used. Other quantities are emitted into the environment. As a consequence of improper treatment, the environment is emitted 450 tons of phosphorus. Even more phosphorus is emitted due to the absence of waste water treatment, although there is a sewage collection system. As the result, 2900 tons of phosphorus is emitted in the recipients. In addition, due to the lack of connection to the sewage network 1400 tons of phosphorus emitted into the environment.
This situation is the result of deficiencies of the current system and small amounts of treated water to be treated with low level of phosphorus recovery.
Based on the status quo of waste water management, three scenarios were developed. Each scenario requires the improvement of treatment, expanding the capacity of the treatment or extension of sewerage networks. These scenarios are:

1. Scenario 1 - improving existing treatments of waste water to maximize the extraction of phosphorus (tertiary treatment),
2. Scenario 2 - connection of the entire existing sewerage network system to waste water treatment plants.
3. Scenario 3 - connect the entire population to the sewage network system and waste water treatment. Depending on the scenario, the amount of phosphorous that can be extracted from the waste water varies.

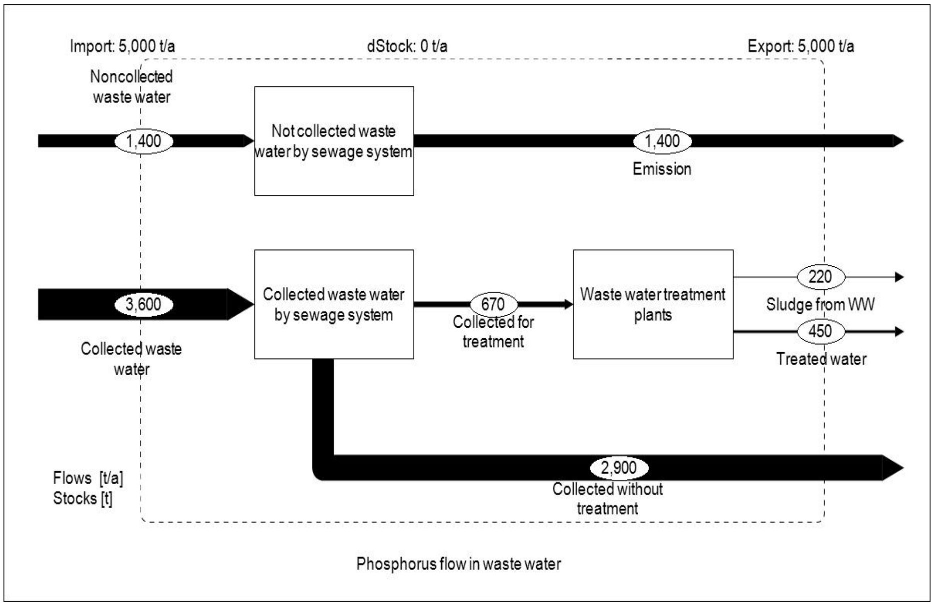

Figure 1. Phosphorus flows in waste water - status quo

In the scenario 1 there is no change in the quantity of treated wastewater and, therefore, the amount of phosphorus that can be separated is limited. In this situation, 12% of total phosphorus in wastewater could be separated. This is due to low rates of connection of sewage network to the treatment plants. Total emision in the environment is 4400 tons of phosphorus. This scenario is shown in Figure 2.

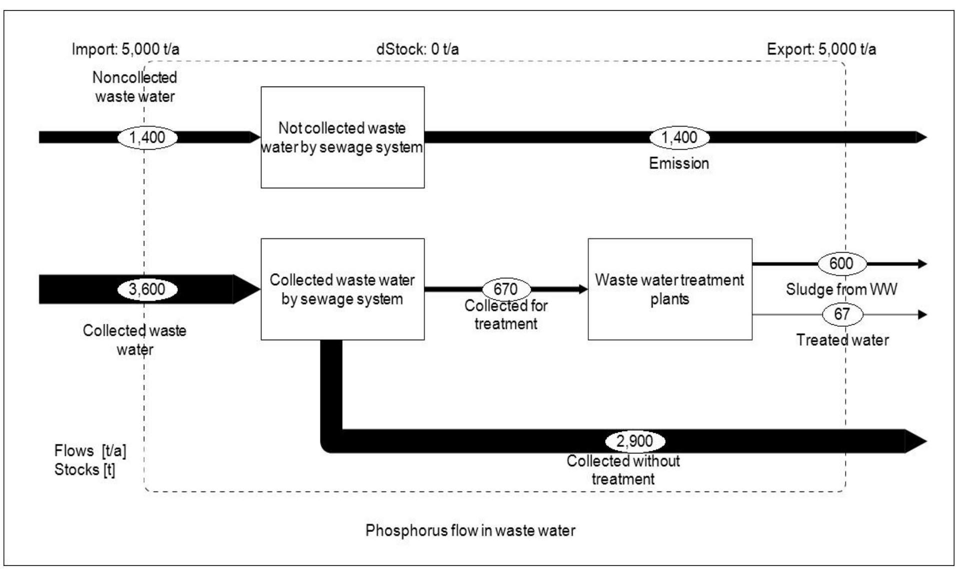

Figure 2. Phosphorus flows in waste water – Scenario 1

In the scenario 2 as complete sewage system is connected to the treatment plants, amount of phosphorus that could be separated are significant larger. In this way 64% of phosphorus could be recovered. Phosphorus emission into the environment is around 1800 tons. In Figure 3 scenario 2 is presented.

Connection of the entire population to the sewerage system and treatment of all the waste water is shown in scenario 3, presented in figure 4. This scenario is not realistic but it serves to show the total potential for phosphorus recovery. Total annual potential of phosphorus in wastewater is 4500 tons.

In all scenario sewage sludge is generated. For treating sewage sludge there are three options: burning, landfilling, or agricultural use as fertilizer. Phosphorus recovery by direct use of sludge as fertilizer on agricultural land is questionable because of pollution content in sewage sludge [9, 10].

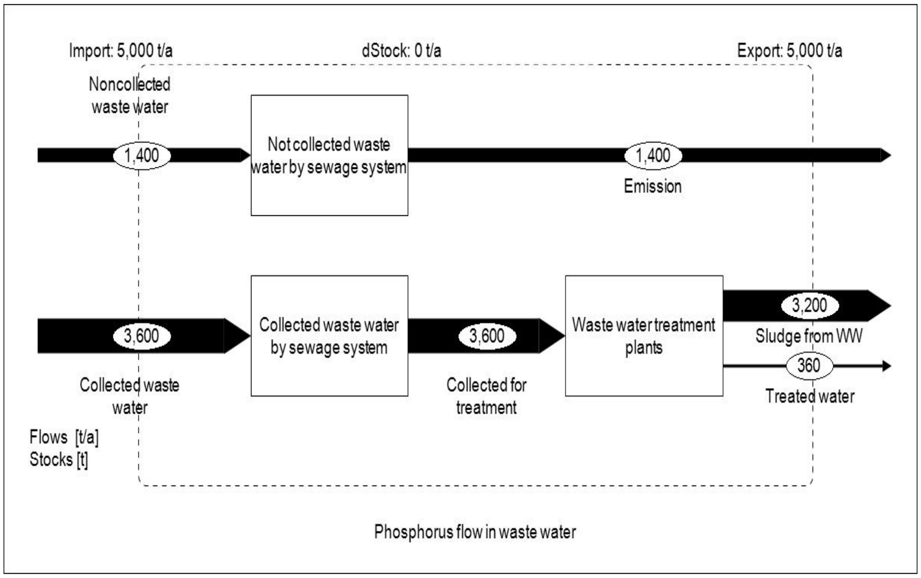

Figure 2. Phosphorus flows in waste water – Scenario 2

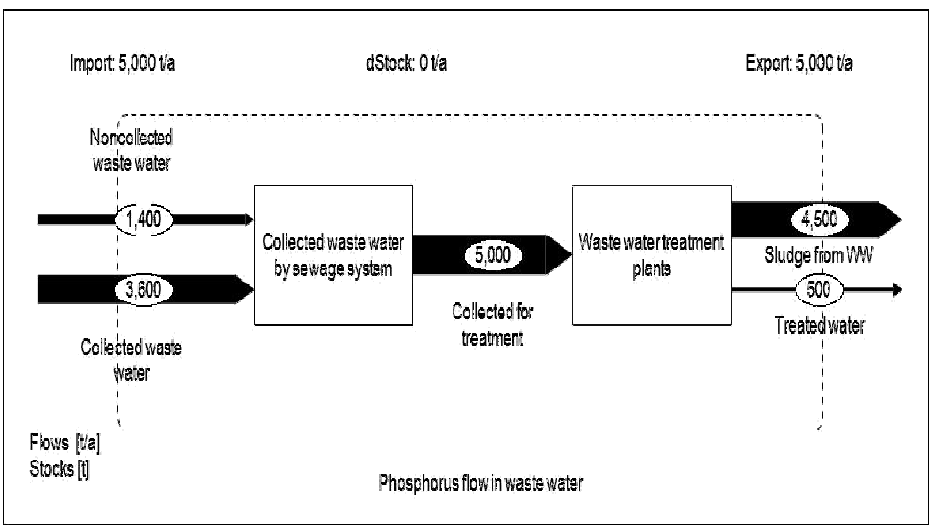

Figure 3. Phosphorus flows in waste water – Scenario 2

4. Conclusion

The current situation in waste water management system is critical and it is necessary to control the problem of environmental pollution. Together with the solution of this problem, an alternative source of phosphorus can be obtained. According to the paper results it can be concluded that the wastewater management in Serbia has potential of phosphorus reuse as a resource, but it must go through major changes. MFA obtained results are useful to simulate future changes of waste water management system due to the changes in technology and legislation.

References

5.1. Journal Article

[1] O.Cencic, H.Rechberger, Material flow analysis with software STAN, *Journal of Environmental Engineering and Management,* 2008, Vol. 18(1), pp. 3-7.

5.2. Conference Proceedings

[1] K.Ashley, D.Cordell, D.Mavinic, A brief history of phosphorus: From the philosopher's stone to nutrient recovery and reuse, *Chemosphere*, 2011, Vol. 84, pp.737-746.

[2] D.Cordell, A.Rosemarin, J.J.Schröder, A.L.Smit, Towards global phosphorus security: A systems framework for phosphorus recovery and reuse options, *Chemosphere,* 2011, Vol. 84 pp. 747–758

[3] PSUPCEP - Provincial Secretariat for Urban Planning, Construction and Environmental Protection, Autonomous Province of Vojvodina, Republic of Serbia, Korišćenje i tretman komunalnih i industrijskih otpadnih voda u Republici Srbiji, May 2015.

[4] S.Vujović, N.Stanisavljević, B.Tot, D.Ubavin, L.Lepojević, Biodegradable waste treatment as opportunity for phosphorous recovery in Serbia, CYPRUS 2016 4th International Conference on Sustainable Solid Waste Management, 23-25 June 2016, Limassol, Cyprus

[5] Danube River Basin District Management Plan – Update 2015, Published by: ICPDR – International Commission for the Protection of the Danube River, available at: www.icpdr.org

[6] N.Stanisavljević, P.H.Brunner, Combination of MFA and SFA – a powerful approach for decision support in waste management. *Waste Management & Research,* 2014, Vol. 32 (8), pp. 733-744

[7] P.H.Brunner, H.Recheberger *Practical Handbook of Material Flow Analysis*, Lewis Publishers, USA, 2004.

[8] M.B.McBride, Toxic metals in sewage sludge-amended soils: has promotion of beneficial use discounted the risks?, *Advances in Environmental Research,* 2003,Vol. 8(1), pp 5–19.

[9] P.S.Kidd, M.J.Domınguez-Rodrıguez, J.Dıez, C.Monterroso, Bioavailability and plant accumulation of heavy metals and phosphorus in agricultural soils amended by long-term application of sewage sludge, *Chemosphere*, 2007, Vol.66(8) pp. 1458–1467.

[10] B. Fjällborg, G. Dave, Toxicity of Sb and Cu in Sewage Sludge to Terrestrial Plants (Lettuce, Oat, Radish), and of Sludge Elutriate to Aquatic Organisms (Daphnia and Lemna) and its Interaction, *Water, Air, and Soil Pollution*, 2004, Vol. 155 (1), pp. 3–20.

[11] R.P.Singh, M.Agrawal, Effects of sewage sludge amendment on heavy metal accumulation and consequent responses of Beta vulgaris plants, Chemosphere, 2007, Vol. 67(11), pp. 2229–2240.