MEASURES TO IMPROVE ENERGY CONSUMPTION IN WASTEWATER TREATMENT PLANTS (NODAL NETWORKS)

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Abstract
In normal way 99 percent of sewerage systems are systems with branched grids and with unique waste water track.
The technical name indicates the size of the sewage treatment plant at 2Quz.orar.max. (unitary sewerage system) and at 1Quz.orar.max (separate sewerage system), including taking into account the prospective flow. These flows cause great problems in the first years of operation for two reasons: big differences in actual flows and very large differences between Qzi min; Qzi max.
The paper work proposes to carry out a transformation of the gravitational sewerage network into a nodal network, which by means of automation can be used in the same sewerage network to use different water transport routes to capitalize the volume of sewerage network compensation. So the flow Qzi.med will be at the entrance to the wastewater treatment plant.
This leads to the efficiency of the treatment and the reduction of the power consumption of the blower station.
The paper work also shows the possibilities of reducing the energy consumption of the second main consumer in the wastewater treatment plant, respectively the wastewater pumping station.

Keywords
Wastewater treatment plants, energy consumption.

1. INTRODUCTION

As they increase in population the localities have an increase in the dynamics of the flow / wastewater needs, within the locality's administrative division. If the total locality area has residential, social, economic areas, then, depending on the inhabitant's day program, with their movements during the day, there is also the displacement of the waste production. In this case, the public sewerage network (RCP), sized at $Q_{uzormax}$, in order to meet any flow rate produced at any given time, operates at certain times at the projected flow rate, but for a very long time it operates below this flow rate, any network having remarkable capacity available for transport.

2. PRESENTATION OF THE PROPOSED SOLUTION

Given the access to measurement technique of the network state (real-time flow rate) and transmission of this information to dispatchers due to the speed work of computers related to the network characteristics (sections, roughness, slopes, flows, etc.) it is possible to know at any moment the flows state in the sewage systems.

Given that the flow rate in the sewage treatment plant is the public sewerage network final flow and knowing that this flow is conditioned by the transport time (length and water speed in the collector), it is possible to modify the "fixed" state of the branched public sewerage networks and transform it into nodal networks, thus capitalizing on the storage capacities of the public sewerage network.

In this way, the gravitational network with fixed paths is transformed into a dynamic branch network (nodal network), greatly diminishing the maximum flow rate in the sewage treatment plant.

3. PRESENTATION OF NODAL NETWORK

The dynamically branched (nodal) networks (Figure 1) are networks that (in a plan view) act in the same way as the static ones, only that they have nodes that can receive water from "n" directions and allow discharge from the node also in "n" controlled directions. The network control nodes have instrumentation that can transmit the flow from the node to the dispatcher; the dispatcher analyzes the overall situation, makes the decisions and sends it by radio or G.S.M. to the equipment of the node, equipment (electro-station, etc.) which regulates the flows on each outlet of the water from the node. [1, 5, 7]

This type of network allows the use of existing compensation volume in the public sewer network. The network has the great advantage of being able to attenuate $Q_{or.max}$ in the public sewerage network respectively $Q_{or.max}$ can be obtained at the entry to the Treatment Station.

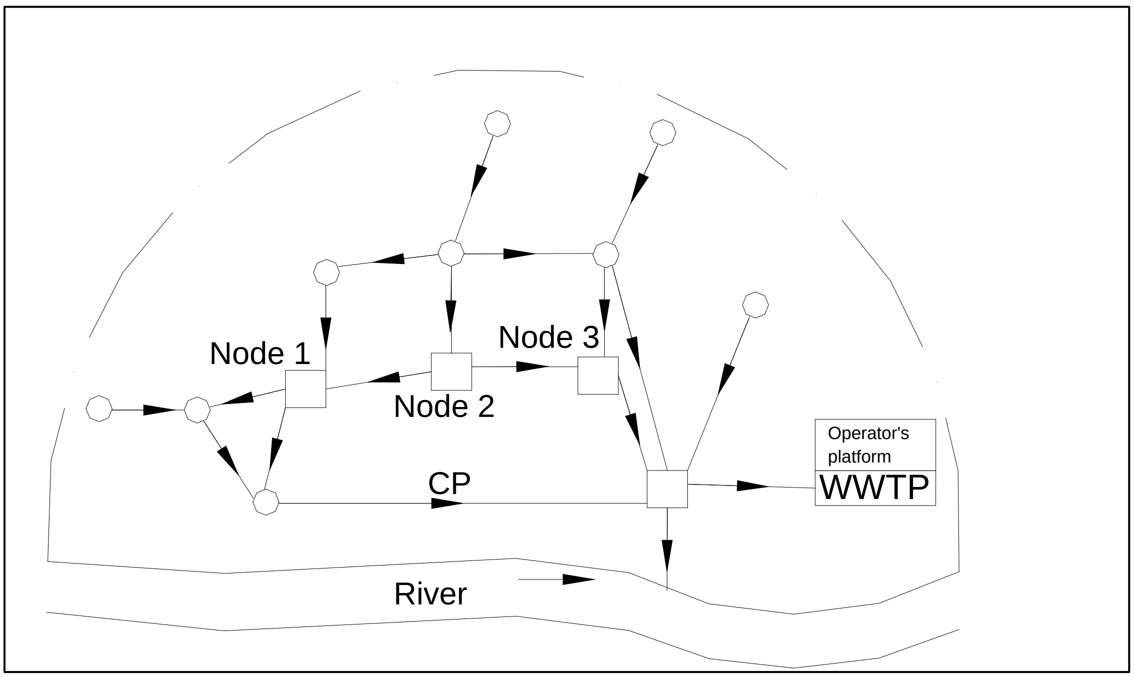

Figure 1. Diagram of a Dynamic Branched Sewer Network
CP - main collector, WWTP - wastewater treatment plant

The transformation of the public sewerage network (RCP) from a branched network into a nodal network is based on a study of flows (and if possible on the quality of the sewage water) on the branched network sections.

A branched network is based on the principle that in a node it can receive water from "n" directions, but it goes mandatory on single direction from the node (Figure 2.a).

The nodal network is based on the principle that in a node can enter water from “n” sections and can also discharge waters on "n" sections (Figure 2.b).

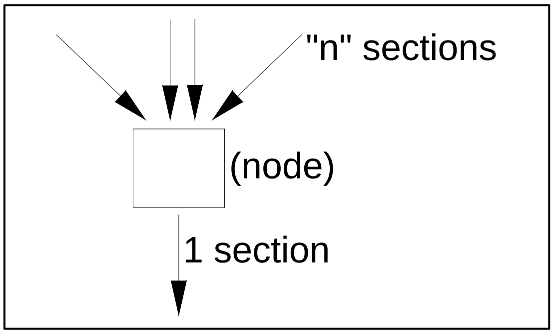

Figure 2.a. A node from a branched network

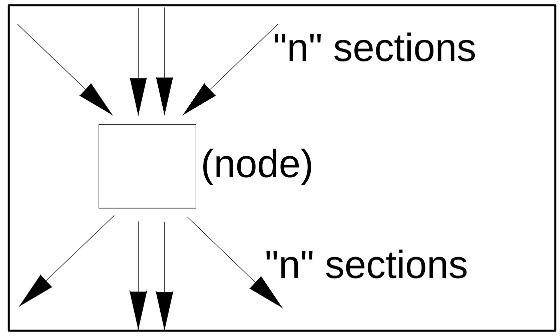

Figure 2.b. A node from a nodal network

From the branched network, a number of "i" nodes are to be nominated in order to modify the network into a nodal (gravitational) network. In this situation, the node is equipped with flow meters for the entering water and equipments and flow rate control devices on the downstream exits (electro-sluices and electro-valve) (Figure 3).

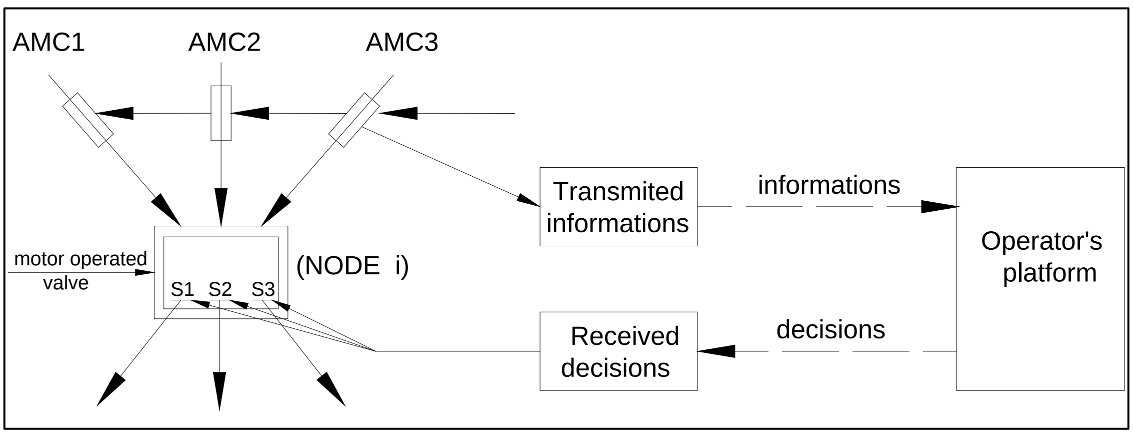

Figure 3. Equipment of a NOD with input flow meters and adjustment devices

It can be seen in the above figure what an important advantage in the treatment plant operation is the leveling of the influent flow, and what great advantages are achieved by the considerable sludge reduction for the necessary objects and respectively the reduction of the technological equipment.

4. FLOW COMPENSATION OPTIONS

In this situation, it is strictly necessary to solve this desideratum, which is possible in the following variants:

- Option I: - sewerage flow compensation in the public sewerage network;
- Option II: - sewerage flow compensation in specific constructions and facilities upstream of the wastewater treatment plant. [2, 4, 6]

Option I - sewerage flows compensation in the public sewerage network

Flow compensation in the sewerage network can be done as follows:

I.A Compensation by keeping the branched gravity sewerage network

In this situation, the compensation is only made when the network has pumping stations located in different places (by geo-topographic and network layout), pumping stations which can be equipped with compensating basins in such a way that at maximum flows or storms, the reservoirs (tanks or polders) to store flows and, at minimum networks flows, the pumping stations to pump from the clearing basins the flow differences required in the public sewerage network. Thus, at the entrance to the treatment station constant flows can be obtained. When there are several pumping stations, it is necessary to create a dispatcher that pools the information from the public sewerage network and the pump stations buffer basins which are then processed in order to make decisions by remotely automating and transmitting the operating system mode.

I.B Compensation with transformation of a gravitational branched sewerage network into a gravitational nodal network

This option proposes to compensate the flows in the public sewerage network by increasing or decreasing the water path from the producer to the treatment plant. Also, in this situation, the flow hydraulic conditions can be monitored throughout the collector.

This is extremely effective when applying to existing networks because:

- most networks were designed before 1989, when an over-dimensioning was made on the basis of the five-year programs;
- after 1989 due to water consumption measuring, the water consumption decreased at least 3 times;
- there are very large reserve volumes when designed in a unitary system;
- instead of water running on "2 ... n" sections at a lower speed than the self-cleaning speed, circulation on a collector is preferred, cumulating the flows and increasing the speed above 0.7 m/s;
- it requires a minimum investment;
- there are computational programs for automatic sewerage management.

Option IIa - Compensation of sewerage flows in specific constructions and installations upstream of wastewater treatment plants

Overview

In this situation, the compensation can be achieved with the minimum of the objects from Figure 4.

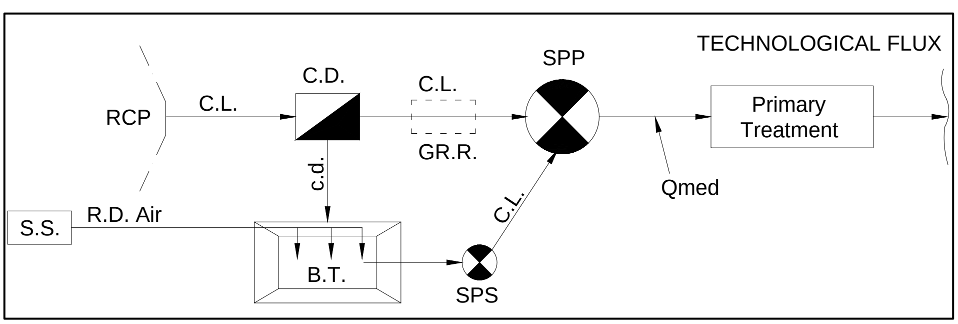

Figure 4. Constructions and installations for flow compensation
R.C.P. - public sewerage network; C. L. - link channel; CD. - spill chamber; CD. - spillway; B.T. - buffer pool; S.S. - blower station; R.D. air - air distribution network; S.P.S. - secondary pumping station; GR.R. – coarse bar screen; S.P.P. - main pumping station
Qmed - influent average flow

Taking into account the flow variation in the public sewerage network, hydraulically we can operate in the following hypotheses:

- hypothesis 1: $Q_{or.uz.} > Q_{uz.med}$ (Figure 5.a.)

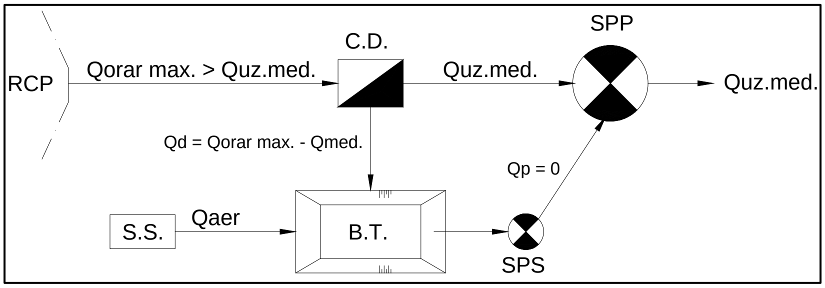

Figure 5.a. Operating hypothesis 1, $Q_{or.max.} > Q_{uzmed}$

- hypothesis 2: $Q_{or.uz} \equiv Q_{uz.med}$ (Figure 5.b.)

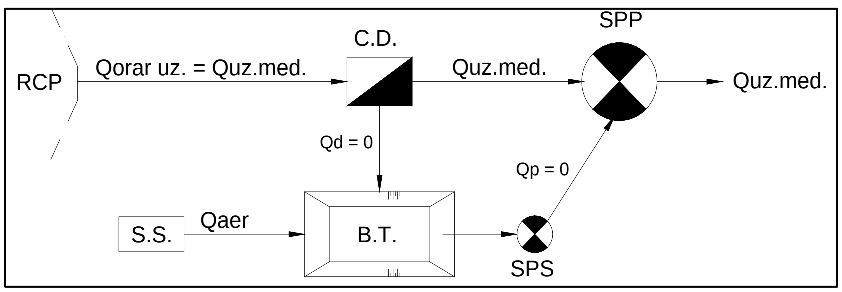

Figure 5.b. Operating hypothesis 2, $Q_{or.uz} \equiv Q_{uz.med}$

Based on this information and the daily flow rate coefficients in the case of constant drinking water supply, a chronogram of influent flows can be made. (Figure 5.c) [5, 7, 9]

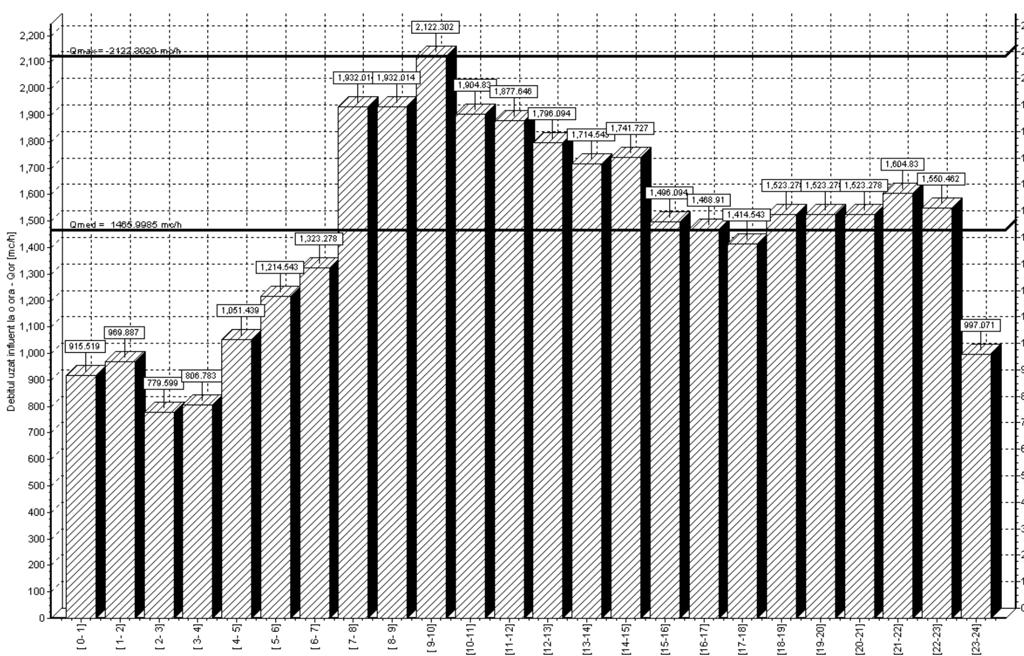

Figure 5.c. Chronogram of influent flows

- hypothesis 3: $Q_{or.uz} < Q_{uz.med}$ (Figure 5.d.)

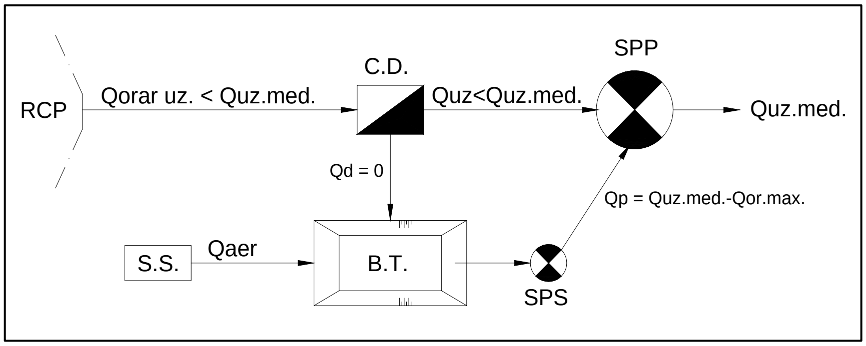

Figure 5.d. Operating hypothesis 3, Qor.uz < Quz.med

Option III - Total - represent measures both in the public sewerage network and in the treatment plant (option I + option IIa).

5. THE NECESSITY TO APPLY THE SOLUTION

Sizing and checking flows for a sewage treatment plant are in accordance with the technical regulations in force in the wastewater legislation [6, 8].

a) *Over-dimensioning of wastewater treatment plant objects and equipment* by designing to 2 $Q_{uz.or.max}$ leads to the following difficulties:

- very high investment values;
- exaggeration of buildings and installations.

A sewage treatment plant works very well when the flows and pollutants amount are those in the project. The higher the investment, the worse the station will work by increasing the retention/treatment time and by making unjustified costs.

b) Establishing the design flows for the wastewater treatment plant is conditioned by the flow forecasting and population development. These have an overwhelming importance on the flow forecast.

In the current sizing practice at design flow rates (Q_{zimed}), the prospective flows for 20-25 years, require $Q_{uzormax}$ at least 5 times higher than the initially Q_{zimed}. If this is added, the fact that the technical rules indicate for the unit sewerage systems a design flows of 2 $Q_{uzormax}$, then the design flows and the investment realizations are 10 times higher than the current requirements.

c) *Failure to create so many treatment modules*, and even if they are done, they are not justified to stay idle for a very long time.

d) *Wastewater treatment plants* should be regarded so that the water treatment costs are optimal and minimal in value. This can only be achieved by correlating flows, quantities of pollutants and treatment costs.

e) *Wastewater treatment plants can not be independent* - the cost of wastewater treatment is strictly conditioned by the operation of the *public sewerage network, which ideally has to bring into the station as influent flow a constant flow at any hour of the day/night.* This greatly reduces operating costs.

f) *Modulation is a operating solution but not of investment.*

In the current design and implementation applications it is found that the construction of compensation basins within the treatment plant is mainly made with the target of rain flows in the first 15 minutes but can also be used to compensate the waste flow when there is no rain. (E.g. wastewater treatment plant in Homocea, Vrancea County and Alexandria, Teleorman County, Figures 6.a and 6.b).

Figure 6.a. Compensation basin – Homocea

Figure 6.b. Compensation basin – Alexandria (the empty basin)

6. CONCLUSIONS

The minimum costs of treating wastewaters will be obtained for a constantly influent flow in a wastewater treatment plant.

This is necessarily achieved by correlating the functioning of the public sewerage network with the needs of the station. There must be no separation of production activities strictly on the sewerage network and strictly on the wastewater treatment plant.

Compensation of wastewater flows produced in the sewerage network leads to particular savings in wastewater treatment and total removal of the risk degree on the treatment plant.

As a result:

a) starting the transformation of the gravitational networks into nodal networks, having collector compensation capacities (e.g. sewerage network of Iasi municipality);

b) public sewerage networks have pumping stations - in the new European programs they have the money allocated for the dispatching of the wastewater transport (e.g. the sewerage network of Vaslui municipality);

c) the construction/existence of compensation basins on the sewerage networks.

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