STRATEGIES FOR SEWAGE TREATMENT IN RURAL AREAS

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Abstract

The application of the Water Framework Directive and the Directive 91/271/CEE conditions the objectives of the Plans of Wastewater management approved in different Autonomous Communities in Spain. In all the lines of performance the treatment of the towns with more than 2,000 e-i has been prioritized. It is foreseeable that in one second phase the smallest towns will study. In this case, the collective, individual or decentralized systems will be valued of wastewater management. This paper analyzes the present situation of the wastewater management in the rural scope of the province of Lugo by means of a survey in the 67 city councils. The high-priority lines of performance and the methodology for the selection of the suitable technology are defined from the collected data.

Keywords: *Wastewater management, rural planning*

1. Introduction

During recent years in Spain is making a major financial effort to adapt the infrastructure for sanitation and sewage treatment. This is so due the growing awareness about the need to rationalize the use of a limited natural resource as water and the obligation with existing legislation.

The explicit requirement to purify the waste urban water is collected in the European Directive 91/271/EEC (European Commission, 1991). With the aim of achieving the compliance with this Directive approved the National Plan of Reorganization and Purification 1995-2005 (Council of Ministers, 1995) and the Royal Decree Law 11/1995 (B.O.E. 312/1995) transposing EU legislation in our legal framework.

In the case of cores with particular entity, due to the volume and variability of the composition of the treated water, are conditioned to the use of so-called conventional systems. In small cores the problem is completely different because the volume of waste is not as important and, moreover, is made almost entirely of organic components. This allows great flexibility to select the best treatment for each core or group of cores considered *(*Muiño et al., 2005*).*

In Spain, the way to assimilate this European normative within the provided period, varies depending on the populational organization of the territory *(*Garcia et al., 2001*)*. In the case of Galicia, where there are the 50% of all entities of the population of Spain, exists with a homogeneously populated territory (INE, 2004). This particular demographic distribution explains the fact that almost 89% of institutions of habited population have a census of less than 100 inhabitants, as illustrated in Table 1.

Population	Cores		Inhabitant	
	Number	%	Number	%
<100	25.625	88,79	664.213	24,15
101-500	2.838	9,83	539.694	19,62
501-2.000	300	1,04	271914	9,88
>2.001-10.000	98	0,34	1.275.0054	46,35
Total	28.861	100,00	2.750.875	100,00

Table 1: Singular entities of population in Galicia according to inhabitants of right 2003 (INE, 2004).

This geographical and demographical reality conditions the wastewater treatment *(*Alvarez et al., 2006*)*. The irregular topography of the region, with a great orographical variability, but without high altitudes, makes it difficult connecting of next cores by collectors.

In Galicia, for the purpose of transposing the European and national legislation to our legal framework were adopted the Law 8 / 2001 (Presidency of the Xunta, 2001) and the drafting of the Plan of Sanitation of Galicia 2.000-2.015 (Presidency of the Xunta, 2001*).*

The Plan of Sanitation of Galicia is focused almost exclusively on the cores of population older than 2.000 h-e believing in the fulfilling of the Directive 91/271/EEC. It must be remembered that in Galicia are no less than 28.763 cores minor than 2.000 inhabitants which agroup almost 54% of the population *(*INE, 2004). In this sense, it is proposed to connect of the cores of more than 100 people. In the case of cores with less than 100 inhabitants, is proposed its connection to an urban agglomeration or their considering as isolated core with individual sanitation.

Although in the Plan of Sanitation of Galicia does not contain the pollution load caused by the livestock, considering the same of diffuse character, the management of wastewater generated by this sector is an issue of paramount importance. The census of livestock of Galicia is close to 900.000 head of cattle, one million head of pigs and about 300.000 head of sheep. However, in rural areas, the influence of this activity in the management of wastewater depends on the type of exploitation and its location *(*Cuesta et al., 2006*).*

We start from a current situation where the availability of existing infrastructures is very uneven in the set of the territory *(*Cuesta et al., 2006*)*. In this reality we have to unite the growing social and legislatitive demand, of new actions that are financed and implemented by different agents (local entities, private initiatives, Deputations, Counseling or the Administration of State).

This situation is compounded by the wide range of technical solutions, adapted to different situations, that now the technology offers us (Cajaraville et al., 2007). Each of the systems of available treatment is associated with different levels of demand in the purification and the necessary investment and, what is particularly important, in maintenance costs.

From the above description of the problem of wastewater management in rural areas seems necessary to promote the coordination of social involved agents. It is therefore important to establish basic standards or recommendations on the use of different technologies and to define the main lines of action for a proper planning for wastewater management in the rural areas.

2. Preliminary approach

Considering the Council as the unit of action, and watershed as planning unit, is proposed an open system that allows us to simulate, considering the reality, different alternatives from a technical, economic and social approach. The variables that must be considered are:

- Demands and needs of purification.
- Economic and technical capacity for the proper maintenance and functioning of installations.
- Ecological factors of the receiving environment and social factors of acceptance.

To identify the possible locations of the WWTP and the most appropriate treatment systems, it needs to start with the knowledge of the characteristics of wastewater, the legal conditions and the desired quality in the effluent (Cuesta et al., 2006). It is always essential to seek the balance between the cost of installation and performance while minimizing the production of waste and try to obtain profits when this is possible. Furthermore, we must link the different alternatives in the purification with the alternatives in the design of sanitation networks.

In this way, at different levels or stages, it is necessary to assimilate the current situation and generate alternatives to the raised problem. Thus, in the definition the initial data relating to a council, it is obligatory to consider the following aspects: (Muiño et al., 2005)

- Points of current discharge: geographical location, and characteristics of the discharge and characteristics of the receiving environment.
- Typification of the basic characteristics of different discharge depending on the flow and seasonality, population (number, type and forecasts), organic load and possible individual products.
- Existing infrastructure of sanitary and purification.
- Elements of demographic and economic character.
- Environmental and social characteristics.

Based on existing data, the next step is the location and dimensioning of the potential points the purification and establishment of potential clusters. For this, we must assimilate a number of sections such as:

- Defining of treatments of purification more suited for each core or grouping.
- Location of possible points of discharge and requirements of the receiving environment.
- Basic definition of potential networks of sanitation.
- Elaboration of alternatives and economic evaluation of the implementation and maintenance.

An open design of the system should allow us to pose a problem from different perspectives. In this way we can compare different solutions to a precise problem, analyze the reality of a local entity or watershed (Carballo et al., 2007). This will allow us the selection of alternatives in the design of sanitary networks and support to other planning entities.

The proposed methodology is developed in three different stages and is applied to a pilot basin for the purpose of validating the results for the design of a model of general application. Currently we are working to get results in three small watersheds, particularly in the following rivers: Estanco (Antas of Ulla), Madalena (Vilalba), Ferreira (Guntín) and Mao (Monforte de Lemos), all in the province of Lugo (Carballo et al., 2007).

The methodology described suggests that, once defined the prevailing levels of quality in the receiving environment, through its characterization, we must, in accordance with the characteristics of the generated wastewater, to determine the level of required treatment in each case and, then, to select the most appropriate technology of treatment. In a final phase alternatives of dimensioning and location will be generated and the technical and economic evaluation of them.

3. Characterization of the receiving environment

If is taken as work unit the watershed, then will be characterizated the receiving environment under the Water Framework Directive (European Commission, 2000). This methodology, applied to the definition of ecological status and other characterizations in the pilot basin is based on a complete tour of the river. The roadmap is divided into three phases: information gathering, river tour, sampling and analysis of the results (Muiño et al., 2007).

The phase of gathering information aims to locate, analyze and synthesize all the necessary documentation to know the characteristics, ecological quality and uses of water from the basin. The information collected before of integral tour will allow doing a previous tranches and planning the field work. This step of doing tranches could be amended subsequently, so that they can integrate of logical form all the indicators at the time of the definition of the state of the different tranches of study and the receiving capacity of them.

This phase includes the following tasks:

- Mapping analysis to 1:5000 scale of the basin. Calculation of average heights and slopes.
- Geological and hydrogeological analysis of basins. Analysis the climate of the area.
- Analysis of land use: crop, forest areas, livestock, activities of tourism, socio-economy.

- Inventory of hydraulic existing and future infrastructure for supply and discharges.
- Study of water demand through the interpretation of features practices.
- Hydrological analysis by tranches using methods of simulation (Témez) and data of the foronómica network.
- Analysis of the physico-chemical quality of water from the collected samples in the integral tour of the river.
- Analysis of the biological quality of the river (aquatic vegetation, macroinvertebrates, ichthyofauna).
- Analysis of the natural environment, especially the characteristics of the riparian forest, wildlife associated to riparian environments and areas of natural interest.
- Analysis of different hydraulic factory in the area.
- Study of the artistic and cultural heritage.
- Georeferencing of all elements in a GIS.

In the second phase is observed the integral tour of the entire river, and also the rest of the basin. Throughout this phase should be made the remarks in continuous, sampling and differentiation of the river in tranches (description and qualitative assessment).

The comments in continuous allow recording of all those anthropic condition referring to physicochemical and hydromorphological indicators. Sampling embraces the measure of flows of the municipal supply catchments in order to determine the availability of water, sampling of benthic macroinvertebrates by surber network and its subsequent identification in the labarotary and water sampling for analysis physico-chemical.

As for the differentiation of the basin in tranches our interest is in to describe the hydromorphological characteristics (variation in depth, width of the channel, type of substrate, the presence of fast, backwaters and weirs), the physical-chemical characteristics (analysis of samples and visual quality) and biological characteristics (ichthyological and benthic wildlife of invertebrates). These elements will allow us to make the qualitative valuation by hydromorphological, physical-chemical and biological parameters. WFD specifically mentions three types of indicators:

- Hydromorphological indicators: regime of flowrate, continuity, variation in depth and width, velocity of water, structure and substrate of the bed, structure of the riparian zone.
- Physicochemical indicators: visual quality of the water (transparency, colour, presence of foam, smell), water quality (analysis in laboratory).
- Biological indicators: spatial and temporal variation in the capture of salmonidae species (trout) and cyprinid, taxonomic composition and abundance through indexes TBI and BMWP '. (Jaimez et al., 2006)

The ultimate objective of the phase of Analysis of the results is the definition of ecological status and determining the ability of the river as a receiving environment of wastewater.

4. Definition of the needs in the management of wastewater

Once that the objectives of current quality are known for the receiving environment, it is necessary to determine the pollutant load of issued wastewater. With these data it could establish the necessary level of treatment and technology available alternatives.

4.1. Definition and location of the discharge

In the GIS is necessary to have an inventory of existing discharges and with possible discharges of defined groupings previously. These singular points must characterized and categorized for future generalization.

4.2. Determination of the level of treatment

To determine the level of necessary treatment of wastewater of a specific core it is necessary to consider the local conditions and the objective of defined quality for the receiving environment and the maximum and minimum required limits of the purification.

The guidelines in determining the level of wastewater treatment in the case of small cores in rural areas have that adapted to the previously defined reality assuming limitations on the financial capacity and management.

To set the level of performance of elimination of DBO_5 and MES contemplate us:

- The ability of the receiving environment, taking into account the expected uses of water (maximum concentration of BOD_5 in mgO^2/l and maximum concentration of MES measured in mg / l).
- The pollutant discharged load (total number of inhabitants equivalent of 60 g DBO_5/day).
- Equivalent connected population to systems of secondary treatment.
- Equivalent population that still has not systems of secondary treatment.
- The flow of drought in the water course of the receiving environment with a return period of 5 years.

4.3. Alternative in the purification

Once determined the profits it is proposed alternatives in the different treatments. The primary treatment is reserved for populations who poured into fragile water channels, with a significant dilution and having little severe drought. The secondary treatments are necessary in the rest of cores. They may consist in a primary treatment (optional), followed by a natural treatment or, if necessary, of a conventional treatment.

It is necessary to make a special evaluation in the following cases:

- When the discharge takes place in an Area of Natural Interest or in a particular volume of water susceptible to eutrophication.
- When the discharge takes place in an area with an aquatic life of special interest.
- When the discharge takes place in a volume of water that is used as a source of supply.

- When the receiving channel presents a very strong seasonality.

In the first three cases, is necessary to consider the need to eliminate the ammonia nitrogen. In the third case, also it will be necessary to achieve nitrate concentrations below 10 mg $N0_3$-N per liter. When this limit is exceeded, the system will be provided of a process of denitration.

In the latter case, when exists circumstances of low dilution and vulnerability of the receiving environment, will be a priority the elimination of discharges during the critical period. This can be achieved with an effluent storage or a direct application on the ground.

5. Conclusions

As a final conclusion of this study is proposed the definition of a Support System for decision making which must meet a number of conditions on the geometry of the system and the mathematical structure.

A Spatial Decision Support System in the management of wastewater is a practical application of Spatial Decision Support System (Spatial Decision Support System SDSS). These tools are based on an integrated set of software, which allows helping in determining the optimal location of various equipments. The necessary system must facilitate:

- The exploration of the treated problem, with the aim of formulating hypotheses that get it resolved.
- The generation of alternative abundant and varied solutions.
- A precise assessment (if possible quantitative) of the merits and disadvantages of different solutions.

To meet these requirements are necessary different components: a graphics generator, a report generator, a system of database management, a system of management of mathematical models capable of generating alternatives and solutions and to evaluate them.

As for the geometry of the system, the spatial allocation of infrastructure and services in rural areas is an important engineering problem, with significant economic, social and environmental impacts. In this way, the inadequate situation of a filter system causes unnecessary expenses, lack of consideration of the environmental characteristics produce excess of costs and important nuisance to the population in addition to damaging the natural environment.

It is necessary to determine the characteristics of the WWTP (EDAR), of the emissaries and the sewage network, for its proper digital representation in GIS:

- Spatial distribution of WWTP: Concerning a specific point (or centroid of each of the spatial considered areas). One of the essential elements of the procedures that are discussed later is the obtaining of the location and the consistent distances between offer and demand.
- Spatial distribution of the emissaries: In principle, the offer is always linked to specific points in space and that is due to homes or rural cores.
- Relationship between points WWTP / Emissaries and the sewerage network: To connect points (of offer and demand) and sanitation system are added new linear

elements (tranches), so that each point of reported of offer / demand (which is not located in a network node) with the nodes of the network surrounding it and near that point.

As to the mathematical required structure we should describe the requirements of the model that constitutes it. The objective of this model is to maximize the amount of products of the population, the demand for each item and the distance to the nearest WWTP, ie, the minimum distances between each point with the population and the installation (Lopez-Rubio et al., 2002).

It aims to achieve the maximum spatial efficiency from the viewpoint of the affected population, as the separation between unwanted installations and the set of the population that is the highest possible. The purpose of the model is the maximizing of the minimum distance between installations and the centres of the closer core (Woods & Franco, 1995).

This model raises the concept of maximum spatial efficiency of different way than the previous ones. The objective is to ensure that the shortest distance between WWPT and some of the cores result the possible largest (and thus the nuisances are becomed in the minimum possible), given the spatial distribution of the populated places and raised candidates points.

For the evaluation of the raised solutions is intended to use, as Multiapproach technique, the linear weighted sum of the scores of the various generated solutions, it is assumed the procedure of the linear weighted sum of the established values for each solution on different criteria for to be used for the evaluation. Thus, the solution to get the highest score will be the best solution (Pomerol et al, 2000).

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