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Methodologies for feasibility studies related to wastewater reclamation and reuse projects

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Abstract

About 20% of the total surface water in Europe is strongly threatened due to pollution problems, and 60% of European cities over-exploit their groundwater resources. The European Framework Water Directive established that by the year 2015 "a good ecological state" of all European water resources and a sustainable use of water must be achieved. Wastewater reuse presents a promising solution to the growing pressure on Europe's water resources. However, wastewater reuse implementation in Europe faces obstacles that include insufficient public acceptance; technical, economic and hygienic risks; and lack of regulations. On the other hand, a very important aspect to implement a water reuse project is the feasibility study that was previously developed. Some of the work carried out in a European project called Integrated Concepts for Reuse of Upgraded Wastewater is described herein. One of the most important tasks of this project is to prepare guidelines on feasibility studies for water reuse systems. The defined structure to carry out feasibility studies and some guidelines to obtain an ecological, social and economical assessment is described.

Keywords: Economical aspects; Feasibility studies; Socio-ecological aspects; Wastewater treatments; Water reuse

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1. Introduction

The first technological wastewater reclamation and reuse project started at the beginning of the last century, but, of course, wastewater reuse, especially in agriculture, has been well known since ancient times. Water reuse technologies became well known in Europe and in the US during the past century. The growing need for a reliable water supply has resulted in the development of wastewater reuse in different parts of the world [1]. Many case studies and applications of water reuse all over the world can be considered. Among them, to mention only the most outstanding ones, are the following: The water reuse project in Windhoek (Namibia) for potable uses, the Orange County (California) case in which reclaimed water has various uses (irrigation, groundwater recharge), the Dan Region Project (Israel) for crop irrigation [2], the Queensland Water Recycling Strategy Project [3] and the Canary Islands Water Recycling Strategy (Spain) [4].

The reuse of water is such an important issue that, for example, the IWA has formed a Specialist Group on Water Reuse, and different countries have also created water reuse associations, e.g., the Spanish Association on Desalination and Water Reuse.

Different previous European projects on this issue, for example, CATCHWATER, EWATRO and MED-REUNET, have contributed to establish the first steps to the development and implementation of water reuse in Europe and in the Mediterranean countries.

New steps for water reuse are currently being investigated in work carried out in European projects. AQUAREC has as its main objective to provide knowledge for a rational wastewater reuse strategy as a major component of sustainable water management practices from an interdisciplinary and broad approach. The 17 different partners of the consortium from European countries, Australia and Israel guarantee this broad and interdisciplinary approach.

In the framework of this project, a handbook to carry out feasibility studies on water reuse will be developed, and the application of the methodology described in these guidelines will be verified with three different case studies on water reuse: one in Romanian, another one in Hungary and the third one in the Czech Republic.

2. Definition and structure of a feasibility study

There are three definitions of the word "feasible" in *Webster's Third International Dictionary* [5]. The first is "capable of being done, executed or effected"; the second is "capable of being managed, utilised or dealt with successfully"; and the third one is "reasonable, likely". Within the context of most guidelines, "feasibility" has the following meanings:

- the degree to which a given alternative mode, management strategy, design or location is economically justified;
- the degree to which such an alternative is considered preferable from an environmental or social perspective;
- the degree to which eventual construction and operation of such an alternative can be financed and managed.

A feasibility study is defined as an evaluation or analysis of the potential impact of a proposed project or program. It is conducted to assist decision-makers in determining whether or not to implement a particular project or program. It is based on extensive research on the current practices and the proposed project/program and its impact. It will contain extensive data related to financial and operational impact and will include advantages and disadvantages of both the current situation and the proposed plan. Sometimes, there is a misunderstanding between feasibility studies and case studies. A case study is the real application of the chosen option in a previous feasibility study.

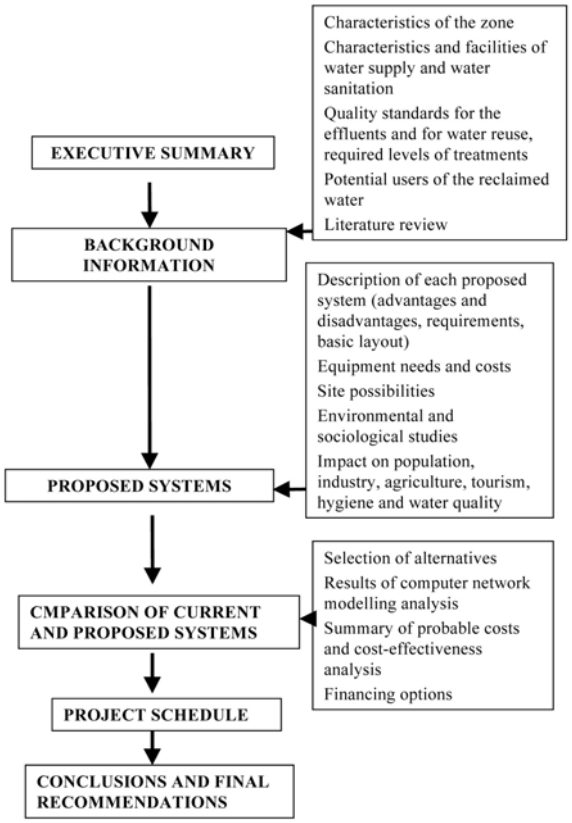

Fig. 1. Guidelines to carry out feasibility studies on water reuse.

As the first step to prepare the guidelines for feasibility studies on wastewater reclamation and reuse, an extensive literature review on feasibility studies has been carried out. As a consequence, a general structure to carry out feasibility studies has been defined (Fig. 1) [6–8].

In this context among the different reference documents consulted, the following ones are pointed out:

1. Guidelines for the preparation of reuse feasibility studies for consumptive use permit applications (Reuse Coordinating Committee of Florida, 1996) [9]. In this document three aspects of a reuse feasibility study are addressed: environmental feasibility, technical feasibility, and economic feasibility, including a present value cost analysis. In this case, in addition to explaining the way to estimate the present value analysis of using current source and reclaimed water, a practice example is showed.

2. Guidelines for preparation of reuse feasibility studies for applicants having responsibility for wastewater management (Florida Department of Environmental Protection, 1991) [10]. This is a very complete document where all the most important issues to carry out a water reuse feasibility study are developed. In this context among the different reference documents consulted, the feasibility studies stand out:

- Fairfield Village (USA) [11]
- Cape May (USA) [12]
- Redwood Shore (USA) [13].

Water reuse must be considered as a part of a general integrated water resource management plan (IWRMP). An IWRMP may be defined as a sustainable approach to water management that recognises its multidimensional character: time, space, multidiscipline (economy, environment/ecology, society, legislation, health issues, technology, political and institutional issues, historical and cultural issues) and stakeholders (regulators/users/providers/neighbours); and the necessity to address, embrace and relate the dimensions holistically so that sustainable solutions can be brought about. In this sense, the cyclic decision-making process to implement a water reuse project is represented (Fig. 2) [14].

In the prepared guidelines on feasibility studies, each one of the headings shown in the general scheme has been fully developed. Moreover, the definition of the extension and type of data to be collected; the definition of the criteria and methods to assess, calculate and compare the effects of selected concept options; the adoption of the ecological integrity methodology; and the identification and development of quantitative indicators for social, economic and environmental efficiency of water reuse have been also carried out. However, due to the limitations of this paper,

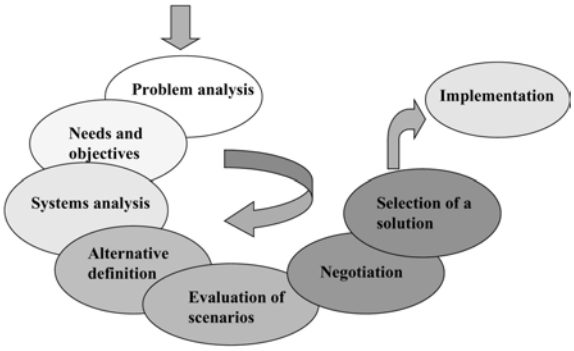

Fig. 2. Cyclic decision-making process [14].

only some of the main aspects to consider for the environmental, the social and the economical assessments are summarised.

3. Environmental assessment

In an environmental impact study the most relevant aspects to consider are the following [15–17]: environment of the old receiving medium and how it will change with the reuse project, environment of the new receiving medium of the reclaimed water, plant diversity, faunal diversity, natural resource utilisation, tourism, visual impact, cultural history, archaeological, human health, hydrology, geomorphology, downstream impact, migration, freshwater requirements, reserve considerations, etc.

In order to know the influence of a wastewater in a receiving environment, both biotic and abiotic indicators are taken into consideration. In the first group are phytoplankton, macroalgae, angiosperms, benthic invertebrate fauna and fish fauna. Abiotic indicators are thermal conditions, oxygenation conditions, salinity, acidification status and nutrient conditions.

In the case of irrigation with treated water, changes in the soil characteristics for long periods of time should be studied. In this sense, boron, sodium, nitrogen, and chloride concentrations should be taken into account. These types of compounds could also affect groundwater. Moreover, the tolerance of the different types of crops to these types of compounds is also different.

Special attention should be put on risks basically for human health. Issues such as distance between potable and reclaimed water pipelines, possible consequences in case of a leakage or reclaimed water pipelines breaking, parks and gardens irrigation during the night, and so on, should also be considered.

4. Social assessment

In order to improve the social acceptance of water reuse, information about the different benefits (environmental, economic such as impact on tourism and water price) of water reuse and a information session about the different terms (water, wastewater, reclaimed water, water treatment, water quality, etc.) are needed, as information has been proved to have a positive influence on user acceptance [18–22]. Consultation components and activities to carry out include project summary document, free telephone information lines, newsletters, fact sheets, a web site, press advertisements, community information sessions, stakeholder meetings, planning focus meetings and community focus group research. A proposed scheme for a public participation program given in the last report of the US EPA [23] is shown (Fig. 3).

Some of the main issues raised during the consultation program are: noise, access problems to different places, damage to structures and properties, the level of treatment of the recycled water, health impact related to the inadvertent consumption of the treated water, possible problems in crop irrigation, price of the recycled water, system connection issues and when the product will be available [15].

The most relevant conclusions achieved in different works carried out about this issue are: a higher level of income and education are

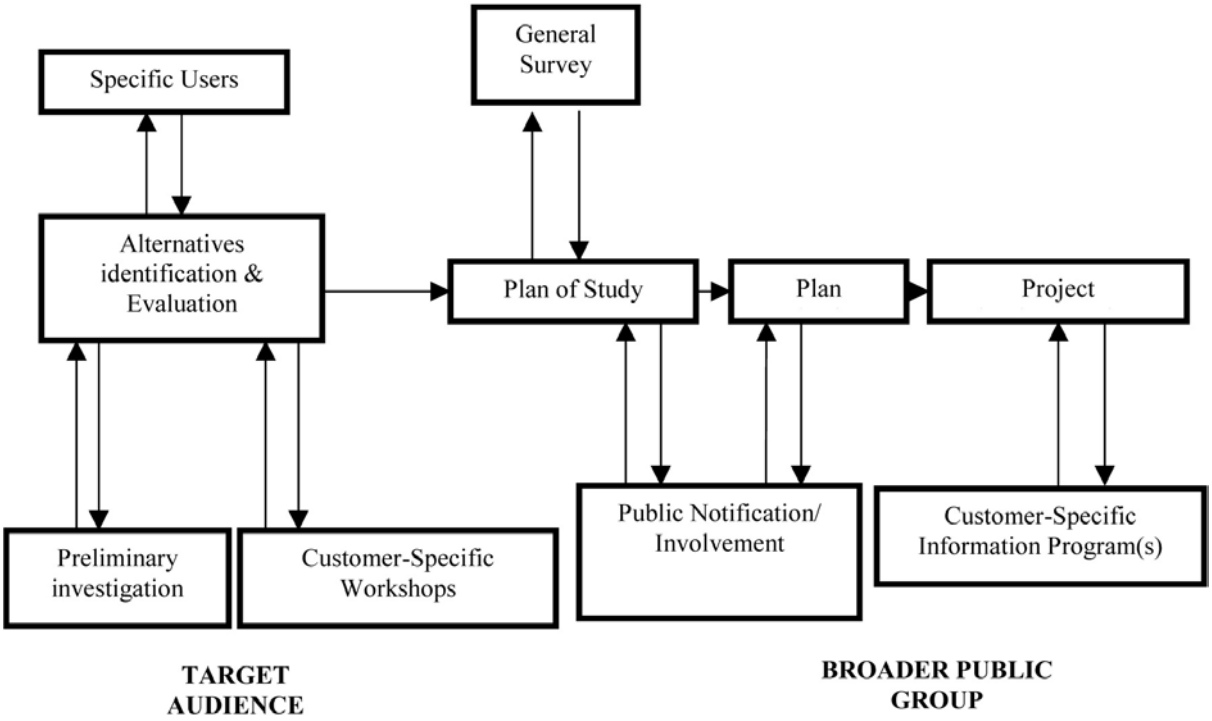

Fig. 3. Public participation program for water reuse system planning [23].

positively correlated with a respondent's willingness to use recycled water. Extra information on the advantages of recycled water has a statistically significant impact on reported degrees of willingness to use recycled water. Information must detailed, timely, accurate and on-going (knowledge of recipients periodically refreshed and kept updated) [24].

5. Economical Assessment

Economical and financial viability is one of the most important aspects in a feasibility study [25–27]. The cost-effectiveness of reuse projects is directly related to the volume of reclaimed water used: the more water utilised, the more cost-effective the project. Irrigation generally provides the highest potential of water reuse. Depending on the need of the resource, there is a minimum flow to consider a water reuse project as cost-effective. This level, although difficult to specify, could be in the range of a flow corresponding to 10,000–20,000 inhabitant equivalents, or the same water needed to irrigate a golf course or a crop extension of 3,500,000 m^2 [28].

On the other hand, in most cases there is no single option that is the most suitable. Two different types of treatments and water reuse applications might be the most suitable option. To increase the use of reclaimed water, different options could be implemented: a higher price of the tap water (high-quality water), a tax for using high-quality waters for non-exigent uses or funding the use of reclaimed water.

In some cases the implemented alternative will be not the optimal one from an economical or technical point of view but the alternative that relies on the approval of the society and thus of

the end users. Thus, apart from the actual cost, the externalities also shall be considered [29,30].

Financing is another very important issue to consider. It must be considered from an early phase of the proposal that its approval can be delayed for a long time. Subsidies cover a number of areas, predominantly: planning; technical assistance and research (pilot studies, etc.), construction costs; actions contributing to regional objectives which are not locally cost-effective and pay-for-performance incentives. Subsidies do not cover (or will no longer cover) operation and maintenance costs. It is worth noting that in the EU there are no guidelines yet to quantify non-monetary benefits of projects, and therefore grants are provided on a case-by-case basis; this also means that good argumentation is an important feature.

Often funding or implementing water reuse projects are based on political decisions. In Spain the political party in the government before March considered the best option to solve water scarcity in Spain by diversion among water basins, but the current government puts a priority on desalination and water reuse [31].

6. Conclusions

The development of a feasibility study prior to the implementation of a water reuse project is a very fundamental step. Water reuse must be considered as a part of a more ambitious integrated water resource management plan. Prior identification of the potential users of the reclaimed water and social willingness of the proposal are two main factors to take into account.

In the framework of the European Project AQUAREC, one of the objectives is the preparation of a handbook to carry out feasibility studies on water reuse. A general structure to develop feasibility studies has been defined. Feasibility studies must be as complete as possible and they have to detail many different aspects (geological, technical, economical, environmental, sociological, and water quality as well as risk issues). Each of these aspects has been developed in the proposed guidelines. Among the different aspects, special attention should be put on economics where possible funding and prices of drinking water and reclaimed water should be studied, as the this aspect is usually the most important one for water reuse implementation. In second place for water reuse implementation is sociological and public acceptance of the water reuse proposal. A programme to increase community awareness and participation in water recycling should be contemplated. Another very important issue is the environmental impact.

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