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Published in:
WATMED 2

2005

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Abstract

Due to political conflicts, the northern part of Cyprus is being under economical crisis. This is employed by environmental problems such as non-organised improvement of residential areas and their effects on habitat. Especially, three main cities where 75 percent of population is crowded, is seriously under the threat of sewerage problems. In this study the comparisons for available sewerage system of three main municipalities is carried to search for urgent investment required among them. This has been done through the Prioritisation Method. The method involves analyses on levels of sanitation, environmental and public health impacts and financial sustainability of the municipalities, which is under the effects of agriculture, residential and industrial areas.

Keywords: Population, Prioritisation Method, Municipalities, Wastewater Management.

Introduction

Cyprus is situated at the far eastern corner of Mediterranean Sea (Fig. 1). Northern Cyprus comprises 38% of the island with an area of 3355 km^2. The three corresponding cities, Nicosia, Famagusta and Kyrenia and their surroundings are by far the most populated area that constitutes 76.7 %, of Northern Cyprus population SPO (1996).

Rapid development of industrial projects, tourism investment, universities and growing population in the island results in a vast increase in the generation of wastewater and its disposal to the environment. Development has also resulted in

large areas of impervious surfaces leading to increase in surface water runoff in the region, flowing directly or indirectly to the Mediterranean Sea.

Nicosia has been already developing its sewage collection and treatment facilities in a nearby village so that it has relieved the pollution load quite considerably Okaygün (2001).

Kyrenia, have been developing its sewage collection in the region but unfortunately although there is a treatment system, it is not efficiently used and the wastewater is directly disposed without proper treatment into the Mediterranean Sea.

Famagusta, with rapid growth in population due to the university, is deficient in wastewater collection such that local solutions are preferred. The main objective of the study is to identify, and provide environmental justification for priority project to be able to define the urgent precautions within the three municipalities. The study assesses the current situation in three municipalities with respect to water supply, wastewater generation and disposal, environmental conditions; proposes evaluation data criteria and completes a selection process to justify which municipality has the urgent requirement for investment. All these dispose of wastewater without proper treatment is clearly putting stress on the various ecosystems within the northern part of island which includes; agricultural lands, forests, river environments, fishing areas, marine environment, tourist areas and residential and industrial areas.

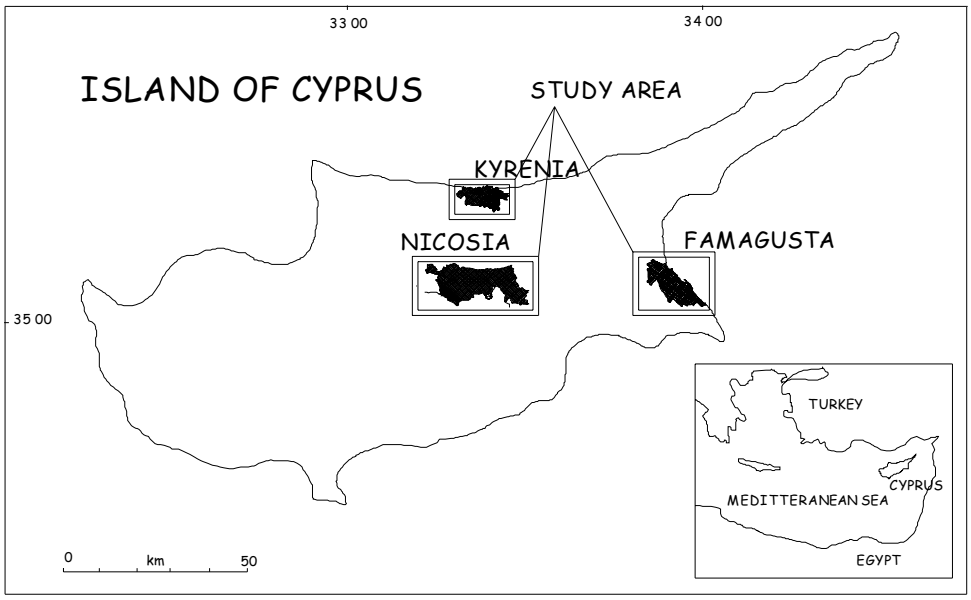

Figure 1. Location map of Cyprus Island.

Prioritisation Calculation

Population is considered to be a very important criterion for the selection of prioritised municipalities suitable for investment. Generally the capital cost of sewerage facilities per capita decrease with increasing city population and higher densities, and the benefit of the investment is maximised Terence, (1991). For this project two key population estimates are considered; present population not served by sewer collection system and present population not connected to a municipal sewage treatment/disposal system.

Recent population growth rates have been quite low in the environs of Northern Cyprus, notably due to uncertainty in Cyprus conflict. Present policies unfortunately force the residents to migrate. Luckily, the recent efforts of United Nations for the peace talks in Cyprus makes the forecasting of future population growth uncertain as policies may be developed to encourage migrated people to relocate back to island.

For this reason it is proposed to only consider existing population figures for the prioritisation process. Population figures for the year 2002 are assumed as the 1996 census figures projected using the average annual growth rates for each municipality between the census years of 1996 and 1997 (Table 1).

Table 1. The 2002 projected population figures of municipalities

Municapility	Population
Famagusta	23,295
Nicosia	36,834
Kyrenia	12,917

Kyrenia is a resort town especially for Turkish families, mainly from rural areas, during the summer period. Many of the summer residences are only occupied for the three months of the holiday period and it would only be during these summer months that income would be generated from the summer residents for water and wastewater services. Accordingly it is suggested that summer visitors to Kyrenia be considered as 25% of actual numbers averaged over the year. It has been broadly estimated that the summer population is twice that in winter SPO (1997). From an examination of the summerhousing areas in Famagusta the summer visitors are similarly assumed as 10% of actual numbers averaged over the year. This gives the above 2002 population figures as the basis for this criterion evaluation. The selection

critera in prioritisation method proposed by considering the sanitation levels through out each city. The environmental and public health impacts of available situation is another important criteria for prioritisation method. Off course, all the above criteria could be solved if financial sustainability could be achieved.

Levels of Sanitation Services

The selection criteria for level of sanitation in prioritisation process are evaluated under two headings. Population which is not connected to the severe system and population that is not connected to the waterborne sewerage system, where domestic wastewater is disposed of on site. In either case the maximum number of people that is not connected will be assigned a score of 15. The scores for the other municipalities would be calculated from the following formula:

$$S_f = \left[1 - \left(\frac{P_{\max} - P_f}{P_{\max}}\right)\right] \times S_{\max} \quad (1)$$

Where S_f is the score for Municipality "f", P_{max} is the population not connected to a sewer system in both cases, P_f is is the population of Municipality "f" not connected to a sewer system and S_{max} is the maximum score as given to the municipality with P_{max}. The overall evaluation score for sanitary services is proposed as the sum of the scores for two criteria applied for each municipality (Table 2). This will give a maximum possible score of 30 points.

The situation where existing areas receive a form of treatment and disposal, but which is not full treatment, is more difficult to evaluate in the prioritisation process. This situation arises in municipalities where preliminary treatment has been provided prior to disposal or not. Upgrading of such treatment system processes can viewed as low priority unless the discharges are causing public health or environmental concern.

Table 2. Proposed selection evaluation for levels of sanitation services.

Item	Municipality of Nicosia	Municipality of Famagusta	Municipality of Kyrenia
Population	36834	23295	12917
Percentage of residential area not connected to sewers	40	90	100
Percentage of residential area not connected to treatment works	40	90	100
Population not connected to sewer	14734	20966	12917
Scoring for population requiring sewer collection facilities.	10.5	15	9.4
Population not connected to sewage treatment works	14734	20966	12917
Scoring for population requiring sewage treatment facilities	10.5	15	9.4
Total Scoring	21	30	18.8

Environmental and Public Health Impacts

It is proposed to evaluate the environmental and public health impacts of existing wastewater discharge practices and associated pollution effects by consideration of the pollution loads and the nature of the receiving waters or discharge media. The proposed evaluation of this criterion is therefore based on the potential hazards associated with the existing wastewater treatment and disposal methods.

The pollution load will be derived from wastewater flow and BOD_5 strength, expressed as mg/l. For domestic sewage this will be assumed at 170mg/l/day. For industrial premises there is a requirement for the firms to provide pretreatment to their wastewater to meet defined standards Geyer (1962). For industrial discharges directly to the environment, such as to rivers, streams or by means of short and deep sea outfalls wastewater discharges standards for BOD_5 strengths are defined for various types of industry. Without going into detailed chemical studies of the wastewater constituents for the particular industries the COD:BOD_5 ratio of 2.5:1 gives a sufficient approximation of the equivalent BOD_5 strengths. There were some industries where no information was available and in such cases typical relevant BOD_5 maximum strengths for wastewater discharges in terms of 24-hour composite

samples are included. For example leather industry is defined by 100 mg/l where oil from oil seeds is taken as 170mg/l.

Generally, in unsewered areas specially in Famagusta, domestic wastewater is discharged to soakage or absorption pits where the liquid part of the wastewater seeps into the soil and the solids are retained within the pits. It is proposed to assign weighting factors to the calculated BOD_5 loads to reflect the sensitivity of the discharge media in respect of risk to public health and the environment as given in Table 3.

Table 3. Weighting factors in respect of risk to public health and the environment

Method of Discharge	Weighting Factor
To the sea by long sea outfall	1.0
To the ground from on-site disposal (soakage pits) – low risk of groundwater contamination	1.5
To the ground from on-site disposal(soakage pits) – potential risk of groundwater contamination	2.0
To the sea by short outfall to just below sea level	2.5
Overground to areas of vegetable gardening (irrigation)	3.0

After application of the weighting factors it is proposed to assign a score of 50 to the highest municipality BOD_5 x weighting factor value. The scores for the other municipalities would be calculated from the following formula:

$$S_f = \left[1 - \left(\frac{B_{\max} - B_f}{B_{\max}}\right)\right] \times S_{\max} \qquad (2)$$

Where S_f is the score for Municipality "f", B_{max} is the BOD_5 x weighting factor value, from the municipality with the highest value, B_f is the BOD_5 x weighting factor value of Municipality "f" and S_{max} is the maximum score as given to the municipality with B_{max}. The demonstration of the proposed selection evaluation for the environmental and public health impacts is given in Table 4.

Financial Sustainability

An assessment of the financial situation based on some relatively simple indicators is proposed for ranking the financial performance of the water and

wastewater utilities of each municipality. This will include the evaluation of affordability of the beneficiaries and willingness to participate.

Table 4 Proposed selection evaluation for the environmental and public health impacts.

Item	Municipality of Nicosia	Municipality of Famagusta	Municipality of Kyrenia
Population	36,834	23,295	12,917
Domestic Wastewater Flow (170mg/day)	6,262 m^3/day	3,960 m^3/day	2,196 m^3/day
Domestic BOD_5 load	3,131 kg	1,980 kg	1,098 kg
Total Industrial BOD_5 load,	650 mg/l	320 mg/l	260 mg/l
Total Domestic and Industrial BOD_5 load	7,201 kg	3,247 kg	1,669 kg
BOD_5 load discharge by treatment plant	2,880 kg	0 kg	0 kg
Weighted BOD_5 load (BOD_5 x1.0)	2,880	0	0
BOD_5 load discharge by on-site disposal – potential risk to groundwater	4,321 kg	3,247 kg	1502 kg
Weighted BOD_5 load (BOD_5 x2.0)	8,642	6,491	3004
BOD_5 load discharge by short sea outfall	0 kg	0 kg	167 kg
Weighted BOD_5 load (BOD_5 x2.5)	0	0	417
Total of weighted BOD_5 loads	11,522	6,491	3,421
Evaluation Score	50	8.2	14.9

Affordability of the Beneficiaries

An approximate estimation is carried for the percentage of average household income taken up by charges for water and wastewater services. The proposed scoring system for this indicator ranks the potential affordability criteria for the beneficiaries by assigning the highest value of 10 to the municipalities where the present charges take up the lowest proportion of average household income and thereby where there is greatest scope for increasing tariffs.

$$S_f = \left[1 - \left(\frac{AI_{\max} - AI_f}{AI_{\max}}\right)\right] \times S_{\max} \quad (3)$$

Where S_f is the score for Municipality "f", AI_{max} is the average household income, from the municipality with the highest value AI_f is the average household income of Municipality "f" and S_{max} is the maximum score as given to the municipality with AI_{max}.

Thus scoring system is expected to favour the municipalities with more efficient operations and maintenance practices. Generally affordability is greater for industry than for residential beneficiaries and it is proposed to use a weighting factor to reflect the potential contributions of the industrial sector. It is therefore recommended that an additional element should be included which takes into account the proportion of industrial wastewater with respect to the total municipal flows. A simple scoring system is used which allocates a highest score of 10 to the municipality with the largest proportion of industrial wastewater flows.

$$S_f = \left[1 - \left(\frac{I_{\max} - I_f}{I_{\max}}\right)\right] \times S_{\max} \quad (4)$$

Where , S_f is the score for Municipality "f", I_{max} is the percentage of wastewater flow as industrial component, from the municipality with the highest value, I_f is the percentage of wastewater flow as industrial component of Municipality "f" and S_{max} is the maximum score as given to the municipality with I_{max}. The two separate scores are then be added to arrive at a total score for this indicator.

Willingness to participate

A simple statement of desire to participate or a simply stated acceptance to make a contribution to investment costs is not a sufficiently reliable indicator for prioritisation process. It is suggested that in addition to willingness to participate, their ability to make a financial contribution should also be examined. This can be done by analysing each municipality's annual accounting statements to assess their recent financial performance.

Actually, the surplus/deficit ratios figures the ability of the municipality to manage the financial budgets with their current operations and highlight their ability to control financial contributions to any capital investments. The scoring system allocates the highest value of 10.

$$S_f = \left[1 - \left(\frac{SDR_{\max} - SDR_f}{SDR_{\max} - SDR_{\min}}\right)\right] \times S_{\max} \quad (5)$$

Where, S_f is the score for Municipality "f", SDR_{max} is the average surplus/deficit ratio, from the municipality with the highest value, SDR_f is the average surplus/deficit ratio

of Municipality "f" and SDR_{min} is the average surplus/deficit ratio, from the municipality with the lowest value. S_{max} is the maximum score as given to the municipality with SDR_{max}. It would then be possible to superimpose the stated willingness to participate on to these criteria to verify that those municipalities with the greater ability to contribute are also willing participants. The overall evaluation score for financial sustainability will give a maximum possible score of 30 points, which must then be factored by 0.67 to allow the maximum defined score of 20 points. In order to demonstrate the proposed selection criteria evaluation the results are given below for three municipalities with differing financial conditions in Table 5.

Table 5. Financial sustainability for different conditions.

Item	Municipality of Nicosia	Municipality of Famagusta	Municipality of Kyrenia
Average household income per month ($)	430	400	460
Ranking score (1-10)	9.3	8.7	10
%age of total wastewater flow as industrial component	28	11	12
Ranking score (1-10)	10	4	4.3
Average surplus/deficit ratio over last three years	1.13	-0.98	0.38
Ranking score (1-10)	10	0	6.5
Willingness to participate by financial contribution to investment costs	Yes	Yes	Yes
Total of Ranking Scores	29.3	12.7	20.8
Evaluation Score (Total of Ranking scores x 0.67)	19.5	8.5	13.9

Discussion and Conclusions

The three selection criteria are compounded into a single matrix for determination of the three municipalities most suitable for investment. The Evaluation Scores are added and the highest scoring municipality is recommended as the priority areas for consideration under investment of this study. The final results are given in Table 6.

It can be easily deduce that all municipalities demonstrated a need for investment in wastewater facilities. None of the existing municipal wastewater treatment and disposal facilities satisfied the requirements of the Turkish Aquatics Products

Regulations 1971 or the EU Urban Waste Water Treatment Directive 1991. All municipalities demonstrated a commitment to improving their wastewater facilities.

Table 6. Overall scores for each municipality

Criteria	Municipality of Nicosia	Municipality of Famagusta	Municipality of Kyrenia
Level of Sanitation Services	21	30	18.8
Env. and Public Health Impacts	50	28.2	14.9
Financial Sustainability	19.5	8.5	13.9
Total Score	90.5	66.7	47.6

Presently the municipalities do not appear to exercise and control or monitoring of industrial wastewater treatment and discharge practices. It is reported that enforcement of the wastewater discharge regulations is not effected and that in many cases industrial wastewater is being discharged without treatment. Maintenance of the sewerage facilities is generally poor and some treatment facilities are bypassed for long periods of time when repairs are required. The selection process shows that the municipality whose wastewater has the greatest impact on public health and the environment, while considering their financial sustainability is Nicosia.

References

Geyer, J. C., Lentz, J. J., (1962). “Evaluation of Sanitary Sewer System Design” Johns Hopkins University School of Engineering.

Okaygün, M., Gökçekuş, H., (2001). Effective potential reuse of wastewater in the TRNC” Proceedings of the 4th International Symposium on Eastern Mediterranean Geology, Isparta, Turkey, 21-25 May.

SPO, 1997. Statistical Yearbook, TRNC, State Planning Organisation Statistical and Research Department Nicosia 1997.

SPO, 1996. Statistical Yearbook, TRNC, State Planning Organization Statistical and Research Department Nicosia 1996.

Terence, J. M., (1991). “Water Supply and Sewerage”, 6th edition, McGraw-Hill.