COMPARISON BETWEEN GRAVITY AND VACUUM SEWERAGE SYSTEMS IN EGYPTIAN VILLAGES

By

Mostafa Ragab Ibrahim

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Public Works Engineering

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Under the Supervision of

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Title of Thesis:

Comparison between Gravity and Vacuum Sewerage Systems in Egyptian Villages

Key Words:
Vacuum sewers; Gravity sewers; Environmental; Social; Institutional

Summary:
Egypt is considered one of the developing countries with rural sanitation service coverage about 10 % only. Conventional gravity sewers is the most commonly used rural sewerage system in Egypt. However, this system has many technical, economic, environmental, and social disadvantages. Vacuum sewers could serve as a good competitor as an alternative system to conventional gravity sewers. Sustainability analysis of both systems was made for economical, environmental and social aspects. For scientific analysis, a sample of 33 rural villages with population range up to 10,000 capita is selected from Egypt.

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Dedication

To My Father, My Mother

My Wife, My Daughter

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Abstract

Egypt is considered one of the developing countries with rural sanitation service coverage about 10 % only. Conventional gravity sewers is the most commonly used rural sewerage system in Egypt. However, this system has some technical, economic, environmental, and social disadvantages. Vacuum sewers could serve as a good competitor as an alternative system to conventional gravity sewers. Sustainability analysis of both systems was made for economical, environmental and social aspects. For scientific economical analysis, a sample of 33 rural villages with population range up to 10,000 capita is selected from Egypt. A statistical analysis is done using SPSS and STATISTICA software where Population and Area variables have the most significant effect on the calculation of annual investment, operation, maintenance, the total annual costs and other different cost component. Investment costs for the vacuum system is less than the conventional one, while operational and maintenance costs play significant roles. Prediction models were obtained based on multiple linear and regression models. It was found that the vacuum system was economically competitive in case of population more than 3,500 to 10,000 capita and areas more than 30 up to 100 hectare taking into account the annual investment and operation and maintenance costs. Low population densities in this range are recommended. Environmentally and socially, the vacuum sewers proved to be better than gravity sewers. Institutional constrains were discussed in details with proposing the recommendations for applying this new system in Egypt.

Chapter 1 : Introduction

1.1. General

According to the UN, about 2.5 billion people around the world still do not have improved sanitation facilities. Despite the fact that sanitation coverage is increasing year after year, it is still below the UN's MDG target. One third of the global population will still be lacking improved sanitation facilities by 2015. For developing countries in Africa and Asia, most of the unserved population is located in the rural areas. Although urban sanitation coverage in these countries can be more than 80%, the coverage in rural areas is still incredibly low at 30-40% [69].

Egypt is an arid country covering an area of approximately 1 million km2, of which its population occupies only 5.5%. The availability of fresh water resources in the country is limited mainly to the Nile River, groundwater from both renewable and non-renewable aquifers, limited rainfalls along the northern coast and flash floods in the Sinai Peninsula. Egypt also practices the use of various types of marginal quality water, such as agricultural drainage water, treated domestic wastewater and desalinated brackish water [2].

Wastewater is originating from domestic, commercial, and industrial sources (often mixed with storm water) are collected, treated, and discharged back into the environment [58]. Discharge of untreated wastewater generated from residences, commercial, institutional, recreational and other facilities causes environmental, public health and other socio-economic problems. Wastewaters contain suspended solids, organics, nutrients, pathogenic microorganisms and toxic compounds. If untreated wastewater is allowed to accumulate, decomposition of organics produces malodorous gases, nutrients stimulate aquatic plant growth, and pathogenic microorganisms have the potential to transmit communicable diseases such as typhoid and paratyphoid fever, dysentery, diarrhea, and cholera, etc. Due to the infectious nature of these organisms, they are responsible for thousands of deaths each year in areas with poor sanitation, especially in the tropics. In addition, some heavy metals and bio-refractory organics found in wastewater are toxic and carcinogenic to human life. Wastewater discharged into rivers, lakes, and other water bodies without treatment can be a major source of water pollution, degrading water quality and restricting beneficial use of surface water. Wastewater discharged on the land can cause soil and groundwater contamination [47,63].

Despite the adverse effects of wastewater on the environment, it is roughly estimated that less than 5% of all the wastewater in developing countries receives some treatment before discharge to the environment [78].

Groundwater is an important source of fresh water in Egypt, both within the Nile system and in the desert. The renewable groundwater aquifer of the Nile system is recharged from excess irrigation water as well as leakages from the Nile and the distribution network [2]. Leakage from sewerage system can cause groundwater and soil contamination, especially in area with a high groundwater table. Damaged sewers can cause groundwater and soil contamination with sulphate, chloride, and nitrogen compounds. This is a serious problem in small villages in developing countries, where rely on ground water as a source for irrigation and drinking purposes.