Wastewater project of Tehran: development, challenges and chances

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Abstract

According to the increasing development of urban areas and the extremely fast rise of Tehran's population since the 1950s, one of the main objectives of environmental, social and economical management as well as water demand management is wastewater collection, treatment and reuse. During this period, Tehran's urban area has extended from about 100 Km^2 to approx. 800 Km^2 and its population has reached about 10.5 million people. The wastewater discharge volume in the ground and surface water body through traditional soak away methods is about 550 millions m^3 per year. The major objectives of this research are to investigate the environmental and economical impacts resulting from the above-mentioned situation. Moreover, the short, medium and long-term framework of the project and the provision of water sources for landscape irrigation and agricultural activities in the suburbs using treated wastewater reuse is presented. Furthermore, this paper proposes a management plan of mitigation measures (environmental monitoring and auditing). Economically, the combination of three solutions – governmental financial resources, public private participation and the World Bank loan – is investigated.
Keywords: Tehran, sewage project, economic, environmental impact, financing.

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1 Introduction

In the process of the ever-increasing development of Tehran, the centralization of the population in this city, the necessity of utilizing water resources of the other watersheds and its transport to this city and the pollution of water and soil in the urban zone due to incorrect and non-hygienic removal of sewage may all seriously damage the environmental body of the city of Tehran and result in the occurrence of unpleasant, environmental phenomena. In 1956, Tehran spread over an area of about 100 square kilometers and the population was approximately 1.5 million people. On the strength of the latest official national statistics in 2006, the area of Tehran has increased to an area of over 800 square kilometers and the population has also increased to about 11 million people. The most serious environmental consequences of the urban development process in Tehran are: the destruction of agricultural lands, gardens and natural resources; irregular expansion and establishment of industrial manufacturing units; the crisis of pollution of bed water resources in Tehran; soil and air of the region; the worrisome enhancement of the need to supply water required in accordance with the limitation of the existing water resources; the risk of using polluted water from the main urban flood plains for agricultural activities and the cultivation of summer crops in the southern region and suburbs. The annual water consumption rate in Tehran was approximately 70 million cubic meters in 1961. In recent years it has been increased up to more than 800 million cubic meters. Due to discharging about 500 million cubic meters of waste water into Tehran's groundwater reservoirs, more than one billion cubic meters of the said groundwater reservoirs are polluted and it makes it impossible to enjoy such an existing water resource in a wide area.

2 Tehran sewage project

The Tehran Sewage Project, which covers a population of 10.50 million people, will be completed in 2016. In the final step, the sewage is to be transferred from two separate routes from north to south through a pipe and a collecting tunnel to two separate water treatment plants in the south and southwest of Tehran. The severe problems in the northern and southern parts of the city have meant that the executive studies of the project were initially conducted for 500 hectares of the northern lands and 10000 hectares of the southern lands in Tehran. Tehran South wastewater treatment plant is in the process of establishment with the capacity of 2.4 million people. Its capacity will be enhanced up to 6.5 million people in the final stage (fig.1).

3 Environmental monitoring and auditing

In accordance with the outcomes resulting from environmental studies, the negative environmental impacts of the project must be prevented at the execution step and/or decreased as much as possible. It is proposed that the management Unit of the Tehran Sewerage Company (TSC) develops measures under a

Management Plan framework of which the outline is presented here. The most important measures that must be set for mitigating environmental impacts on the population and economy of the city during the construction phase are noise, vibration, dust, disruption and public participation. Major measures to minimize disturbance during the operation of the project are noise, odors, screenings disposal and visual impacts. TSC is responsible for the implementation of the project while the Department of the Environment (DOE) is responsible for monitoring of discharge to the environment and its effects to ensure that the required standards are met and adverse impacts are minimized.

The DOE is obliged to perform periodical sampling and analysis (weekly and monthly). The day of sampling should be chosen at random on a 7-day basis. Treated sludge disposed of to agricultural land for use as a fertilizer should be regularly monitored for compliance with the DOE or the Food and Agriculture Organization of the United Nations (FAO) standards (for heavy metals in sludge and application rates). The DOE and MOA will ensure that treated sludge is being stored for at least one year prior to its use on agricultural land. Soil in areas where effluents or sludge are used in agriculture will be periodically monitored for heavy metals to ensure compliance with FAO standards. The DOE and TSC will monitor the quality of Tehran's surface waters.

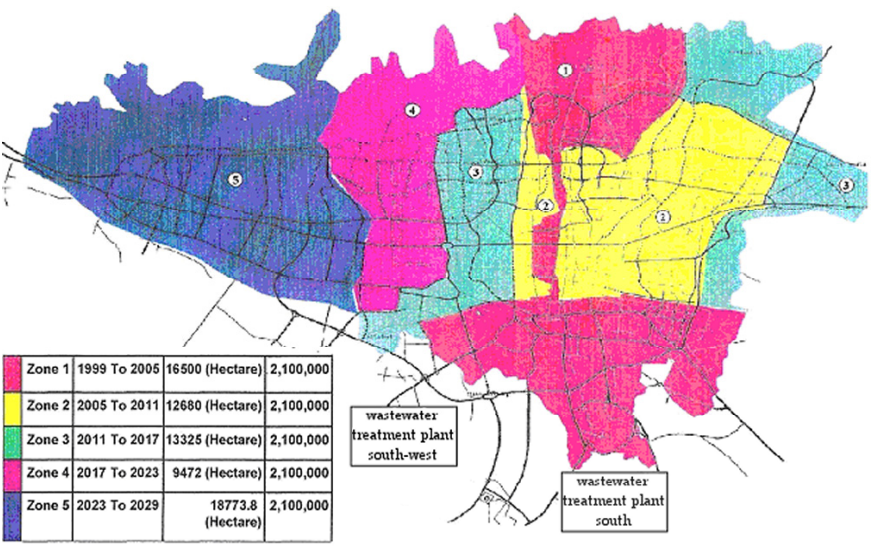

Figure 1: Situation of the districts under coverage (TSC [11]).

The raw sewage inflow at the sewage treatment plant and the treated effluent will be regularly monitored by the TSC for BOD, TSS, total nitrogen, heavy metals, toxic materials, fecal coli forms and intestinal nematode eggs to assess performance. Spot samples will be taken once a day so that the operators can respond to any irregularities. Treated sludge disposed of to agricultural land for use as a fertilizer will be monitored for moisture content, pH, Cd, Cr, Cu, Ni, Pb,

Hg and Zn. These samples will be for use within the TSC, not the assessment of compliance with standards by the DOE. If the effluent quality data show that the arithmetic mean number of nematode eggs is greater than the WHO guideline of one per liter, then the TSC will have to provide suitable tertiary treatment with the proven ability to ensure compliance with the WHO guidelines. The decision whether or not tertiary treatment is necessary should be made on the basis of data from at least one year's operation. The effluent recharged on the South Plain will become part of the groundwater resources by the Tehran Regional Water Authority (TRWA). The Ministry of Agriculture (MOA) will be responsible for monitoring the following in the South Plain: general suitability of crops for consumption, plant tissue quality (heavy metals, boron and arsenic), contamination of crops by pathogens, crop production, health of livestock, nitrogen, phosphorous and potassium content of soil, fertilizers, manure and sludge, moisture retention properties, and pH and carbon-to-nitrogen ratios in soil.

4 Economic study of Tehran sewage project

Amongst the advantages of the project the important ones may be pointed out as: development of national macro economy and regional micro economy; reduction of different dangerous diseases; weather subtilization due to development of 27,000 hectares of irrigating agricultural lands for cultivation of wheat; selling of effluents as in income source; creation of new job opportunities in different areas and related effects in regional and national economy; etc. According to calculations regarding cost-benefit analysis, the investment return period is proportionate to net project sources. Prevention of the wasting of water (discharge of water and sewage into groundwater) and reuse of it for irrigation will make it possible to develop agricultural lands in the south of Tehran. This project is important from the social welfare point of view, nobody will be damaged by it (Parto's improvement theory) and many shadow prices will be returned to the society through it.

4.1 Willingness to connect

To estimate the sewage connection rate in Tehran, four zones were selected and the number of connections within each of them was provided on an annual basis. The analyzing method simply deals with calculation of the average accumulative percent of connections (connection rate) in different years. Plotting the average accumulative connection rates versus time, for the three mentioned zones, it is shown that this rate follows an accelerated increase within the first five-year period, while it tends to increase much more slowly thereafter. Therefore, the time period covering the whole data was firstly from beginning to the fifth year and secondly from the sixth year to the end. The regression fit was realized to be of exponential type of both of the periods. The resulted relationships between the average accumulative connection rate (Y) expressed in percent connected, and time (t) in years, are as follows:

$$Y = 9.1437\, e^{(0.407167t)} \qquad 1 < t < 5 \qquad (1)$$

$$Y = 84.057\, e^{(0.017287t)} \qquad 6 < t < 11 \qquad (2)$$

The values of r squared were 0.984 for equation (1) and 0.642 for equation (2). Based on the regression curve the connection rate in Tehran will be 90% by the end of the fifth year, that is 90% of residents will get connected to the sewage collection system (fig.2).

4.2 Profile of expected connections by expected volumes of water consumption

It is anticipated that 90% of the created capacity will be purchased by the residents during a five-year period. Also, it is predicated that 5% of the created capacity in each year will be allocated in the next year (first year), and 30%, 25%, 20% and 15% of the mentioned capacity will be allocated within the next four years. Therefore, the number of established connections in each year was determined covering a period ending in 2015 AD.

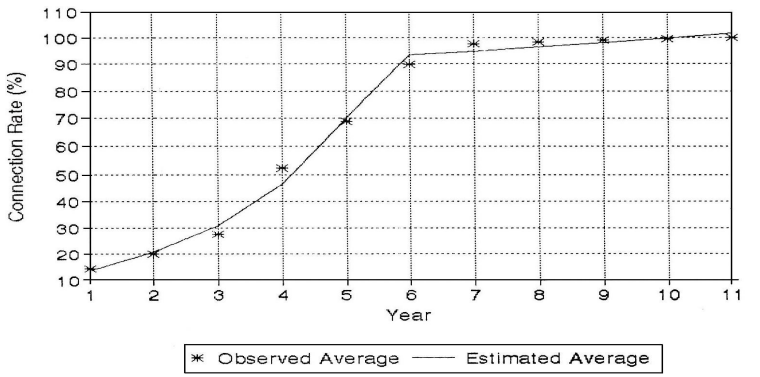

Figure 2: Observed and estimated values of average connection rate.

4.3 Investment costs and operation costs

The total investment cost of the Tehran sewage system is 507.92 million dollars (from 1999 to 2012).

The total operation and maintenance costs of the Tehran sewage system are 231.255 million dollars and the amount of wages payment is 50.827 million dollars (from 1999 to 2028).

The total distribution of income from the water sale is 398.741 million dollars (from 1999 to 2028). The total benefits from treated sludge selling as fertilizer for the first phase of treatment plant will be 900,000 dollars.

4.4 Anticipated increase in agricultural output attributable to the project and non-qualified impacts

The amount of increase in land area under cultivation is exactly proportional to the volume of produced effluent. The annual amount of effluent production is

shown in figure 3 for a 30-year period. The total agricultural benefit is 877.918 million dollars (from 1999 to 2028) (fig.4).

The non-qualified impacts are the expansion of research activities, expansion of public services, preventing emigration of villagers, reduction of side environmental pollution, optimizing water demand management, improvement of groundwater quality, improvement of existing food chains condition, improvement of agriculture soil quality and reduction of competition for agricultural, industrial and urban water consumption.

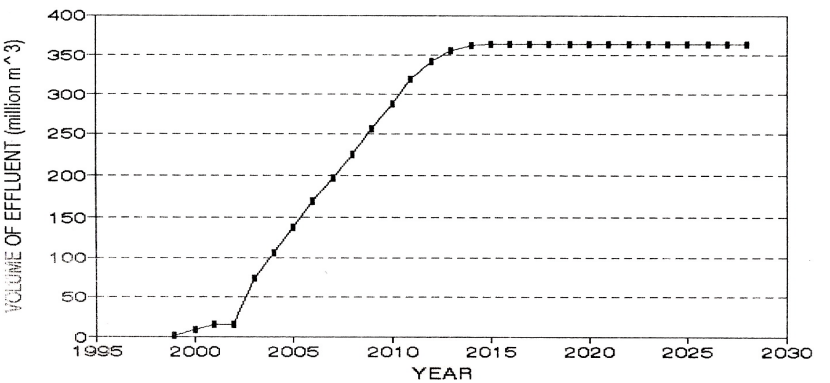

Figure 3: The annual amount of effluent production (Ray Ab Consulting Engineers [7]).

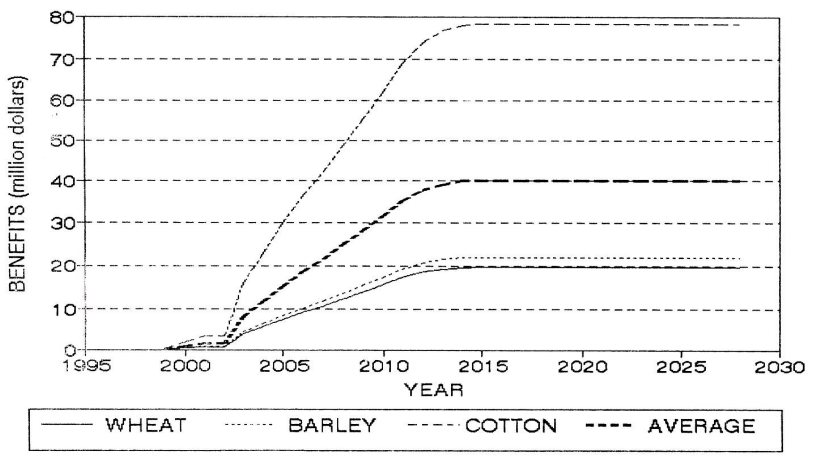

Figure 4: Agricultural benefits (Ray Ab Consulting Engineers [7]).

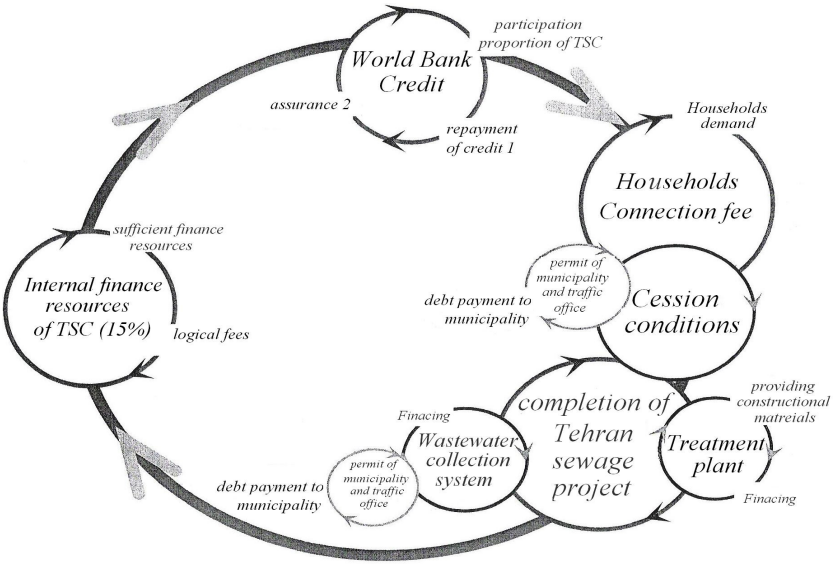

Figure 5: Life cycle processes of TSC (2006).

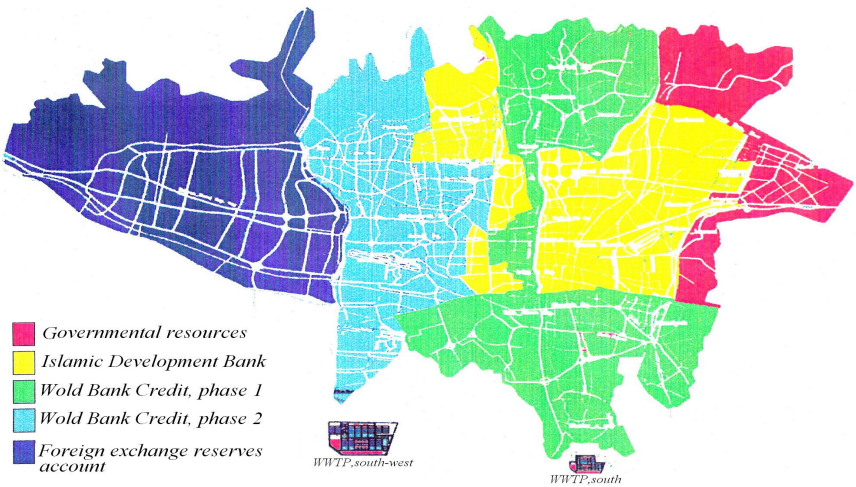

Figure 6: Finance apportionment for different sections of Tehran sewage project (TSC [10]).

5 Conclusion

Tehran has an area of more than 70,000 Ha, and its population has increased far beyond previous assumptions, leading to a rapid expansion in the past few years. This has resulted in a rapid increase in the amount of water consumption and hence generated wastewater requiring proper removal and treatment. This has prompted the Tehran Sewage Company (TSC) to request assistance from the World Bank in securing loans, also the possibility for public private participation. Environmental assessment is required since the project may be associated with diverse and significant environmental impacts during the construction and operation phases. Through the construction of this project considerable problems concerning health affairs and diseases are reduced, new agricultural lands are developed, new job opportunities are created, wasting of water is prevented and sound use of water will cause more productivity in different sectors.

Acknowledgement

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