TURKEY: GROUND-WATER ISSUES IN A COUNTRY WITH A DEVELOPING ECONOMY

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ABSTRACT

As a rapidly developing country, Turkey is facing many of the environmental problems confronted by major industrial countries such as the United States. Swift growth and an increasing standard of living presents a two-fold problem. Waste increases with the growing population, and waste generation on a per capita basis rises along with the standard of living. Although a regulatory framework is evolving to address environmental issues, the financial capability to solve these problems is not often available.

With current regulations and attention focused on the problems of air pollution and solid waste disposal, ground-water contamination is largely ignored. If Turkey is to protect "human health and the environment", the issue of ground-water contamination must be addressed. Through interviews with regulatory personnel, site visits, and a survey of scientific literature, current and potential sources of ground-water pollution are examined.

INTRODUCTION

Turkey is a country of many cultural contrasts, varying geography and a long colorful history. It is also a country facing many difficult economic and environmental challenges. The United States and other more economically developed countries have already met many of the challenges. Hopefully, Turkey, and other countries, will benefit from the past successes and failures of these industrialized nations.

Turkey is struggling with modernization, development and international recognition. Although 98% of the population are Muslims, the government is secular. As a secular and modern state, Turkey strives toward and identifies with the West far more than with the Middle East or Asia. Turkey's desire to become a more active member of the western world has prompted this NATO member to apply for membership in the European Economic Community (EEC). As Turkey pushes for acceptance in the EEC and for wider recognition from the western world, it also faces the domestic problems associated with economic growth.

Providing a sufficient supply of drinking and irrigation water is an issue on which Turkey has placed great importance. Turkey has realized that the supply of safe water to its population is vital to its economic growth. Currently, one of the largest dam projects in the world is being undertaken along the Euphrates River. The Ataturk Dam will transform an entire area in southeast Turkey from an arid plain to a fertile farming region. On a smaller scale, the modern Turkish government has been improving irrigation and water supply through the construction of dams and irrigation canals since the 1930's (DSI, 1977). Included in Turkey's plan to utilize it's water resources, is the development, use and protection of ground water.

As a country with a rapidly expanding economy, Turkey can offer some important insights and lessons to less developed countries and can illustrate the importance of obtaining technical assistance from more economically advanced nations. Turkey is a country experiencing rapid industrialization and economic growth. When compared with the member countries of the EEC, Turkey's GNP per capita is low, but its GNP growth rate is high. Turkey's GNP per capita is, however, higher than other countries such as India and many African nations. As a country located economically between the third world countries and developed nations such as the U.S., Turkey has benefitted from the environmental examples of success and failure provided by the industrialized world and at the same time can act as an example to less developed countries as they begin to grow toward improved economic standards.

ENVIRONMENTAL CONCERNS IN TURKEY

Turkey now faces many environmental problems that the U.S. began to recognize in the 1960's. Among the most evident environmental problems are air pollution, surface water pollution and solid waste disposal. Istanbul is a modern city with a population of about six million. During dreary winter days, air pollution is apparent as one of Turkey's major environmental concerns because, at present, large engines in buses and trucks are burning diesel and most homes and businesses are heated by burning coal. In congested cities such as Istanbul, motor vehicles, homes and factories all combine to create widespread air pollution.

Although air pollution is a pressing problem in Turkey, improvements are expected. What smog is created from the burning of coal may be reduced because of the arrival of natural gas supply lines from the Soviet Union. Also, if Turkey becomes a member of the EEC, it will likely have to meet recommendations issued by the EEC for the abatement of motor vehicle pollution (Cravatte, 1972). Although industrial air pollution is also a concern, stringent controls on industrial discharges may be delayed to prevent smothering industrial growth with expensive treatment requirements.

Because surface water pollution impacts drinking water supplies, irrigation supplies, and the fishing industries, surface water pollution is also of great importance to Turkey. The discharge of industrial wastes is regulated by Turkey's General Directorate of the Environment. However, the quality of the water is monitored by the agency tasked with providing water to large municipalities, the General Directorate of State Hydraulic Works. (Sakar, pers. com., 1990; Torunoğlu, pers. com., 1990) However, this division of regulations and responsibilities can lead to problems when managing the environment in developing countries (Curi, 1987). The Mediterranean Action Plan (MAP) and the subsequent Mediterranean Technical Assistance Program (MTAP) offers funding and direction in the area of monitoring and preventing water pollution along the Mediterranean coast (Turel and Akbostanci, 1987). MTAP is a program whose funding is supplied by member countries comprised of nations in the Mediterranean area and provides for the study and prevention of water pollution to the Mediterranean.

Much like the United States, Turkey faces problems associated with solid waste disposal. These problems include finding suitable locations for the landfills and preventing and remediating the associated ground-water pollution that may result from improperly constructed or managed sites. The current concern is with developing and implementing regulations regarding the construction and operation of landfills, and the collection and treatment of leachate from existing landfills. However, at this time the impact to ground-water supplies from landfills has not been studied, primarily because of a lack of funding for such research (Curi, pers. com., 1990).

GROUND WATER

Ground water in Turkey is used for a variety of purposes. It is used as a primary source of irrigation water in basins where sufficient surface water resources are not available (Balbanan, 1972). Ground water is also used as a supplement to surface water resources for irrigation and domestic water supply. And, more recently, ground water is used as industrial process water (DSI, 1980; Torunoğlu, pers. com., 1990; Tansey 1985), and as a source of geothermal energy (Tan, 1975; Alpan, 1976; Koenig, 1976).

The utilization of ground water in Turkey by modern methods began in 1932, when the first deep water well was drilled as a domestic water supply for the City of Istanbul. In 1952, a ground-water division of the General Directorate of State Hydraulic Works (DSI) was established and in 1960 Groundwater Law No. 167 was passed placing possession of ground water under the State with control given to DSI (DSI, 1980). Additional laws and regulations have ammended and reinforced the intitial legislation (see Teclaff, 1972; Anon, 1975; Hayton, 1982). DSI maintains and operates drill rigs and is responsible for ground-water exploration and the design and installation of ground-water recovery systems for land and water cooperatives. Turkey is divided into 26 regions and control of ground water in each is assigned to the regional office of DSI that encompasses the particular basin (Oldac, 1972).

Turkey's ground-water supplies are particularly vulneralble to contamination from surface sources because a significant portion is produced from carbonate aquifers with karstic characteristics (Ozis, et al, 1985; Lange and Quinlan, 1988). Research in Turkey has focused on ground-water flow in carbonate aquifers and has provided substanial new information on the use of tracers and isotopes in karstic subsurface environments (see Bierchenck, 1964; Dincor and Payne, 1971; Senturk, 1970; Yurtsever, et al, 1986).

Because of the inherent relationship between precipitation and spring flow, research on Turkish sites has contributed substatially to our understanding of the affects of surface waters on the flow in karstic carbonate aquifers (Ozis and Benzaden, 1972; Dunlu, 1972,; Karanjac and Gunay, 1980). Modeling and remote sensing of ground-water flow in carbonate aquifers also recieve considerable attention in Turkey (see Arikan, 1988; Kranjac et al, 1977; Yevjerick, et al, 1976).

Unlike many States in the U.S., ground water in Turkey cannot be exploited without express consent of the government. If a cooperative, municipality or industry wishes to utilize ground water, it must submit to the government an account of the intended use, amount of water required, and location where the water is needed. The regional agency will then examine the basin for estimated yield versus the amount currently being drawn from the aquifer and for quality based on a number of observation wells controlled and monitored by the government. If the DSI determines that an additional well will exceed the "safe yield" of the aquifer, or that the aquifer will not provide the quality of water required, permission to utilize the ground water will be denied. If sufficient yield and quality is available, then ground water may be utilized and the applicant can arrange with DSI to install a well. The applicant will consequently reimburse DSI for costs incurred while installing the well. In this way the cost of ground-water utilization is government subsidized (DSI, 1980; Torunoğlu, pers. com., 1990).

In addition to monitoring the utilization of ground water, DSI also monitors water quality in observation wells. The water samples may be analyzed for as many as 90 parameters (see Table I). The parameters are primarily health-based standards for water quality and the limits are modeled after the World Health Organization standards (Sakar, pers. com., 1990). Although DSI is responsible for monitoring the water quality, the General Directorate of Environment is responsible for regulating pollution discharges from industries and municipalities and for taking corrective actions if illegal discharges are made. Therefore, if ground-water contamination is identified that can be traced to a particular source, the General Directorate of Environment assumes responsibility for enforcement of remedial activities and associated abatement of the source.

As illustrated in Table I, most of the parameters measured in ground-water samples are associated with water quality and not with pollution. In Turkey, as with many developing countries, the majority of ground-water pollution is believed to be related to agricultural activities. This includes ground-water degradation resulting from fertilization and livestock as well as the use of pesticides (Mangat, 1985). However, with the current monitoring program many contaminants in both surface and subsurface waters may go undetected. Until the means are readily available to analyze for such constituents as organic hydrocarbons and organophosphate pesticides, monitoring of ground-water contamination from industrial and agricultural sources may not be fully realized.

As an example of how the system works today in Turkey, we have focused on a particular area and on how the various issues are handled. Bursa, as an example, is a city with a population of approximately 1.35 million. It is a resort area for snow skiing but also contains several industries that have migrated to Bursa to escape higher operating costs in Istanbul. In addition, it is located adjacent to a large agricultural plain. Therefore, DSI in Bursa is responsible for supplying and controlling water and ground water for agricultural, industrial and domestic supply purposes. The major aquifer that is utilized in the Bursa basin currently yields approximately 120 million cubic meters of water per year. Roughly 60% of the ground water produced in this area is utilized for irrigation purposes while the other 40% is used to supplement surface water for domestic supplies. A small percentage is also used for industrial supply purposes, notably an automobile manufacturing facility located outside Bursa (Torunoğlu, pers. com., 1990).

To monitor ground-water drawdown and water quality, 18 observation wells have been installed throughout the basin. Water levels are taken and samples are collected from these wells monthly. The water levels are used to determine the amount of recharge to the aquifer along the mountainous region to the south of Bursa as well as to determine that "safe yield" of the aquifer is not exceeded. The samples collected are analyzed for some or all the parameters shown in Table I. The specific parameters analyzed are determined by the DSI scientists responsible for monitoring the aquifer.

The DSI laboratory in Bursa is equipped with standard lab equipment used to analyze basic

TABLE I

Water quality parameters analyzed by DSI.

		DSI.I.BÖLGE MÜDÜRLÜĞÜ		C.
1-Kayıt No.	2-SPT.No.	3-Tarih Saat	4-Gün	5-Amaç
6- SPT Adı	7-	8-	9-Mesaj	10-

KOD	SİMGE	BİRİM	KOD	SİMGE	BİRİM
011	Q	m3/sn................	049	Mn	mg/l ....
012	h	cm..................	050	Na	mg/l ....
013	Vel	m/sn................	051	K	mg/l ....
014	tw	°C..................	052	Ca	mg/l ....
016	pH	-	053	Mg	mg/l ....
017	EC	mhos/cm.............	054	B	mg/l ....
018	TDS	mg/l................	055	H_2S	mg/l ....
019	SS	mg/l................	056	F	mg/l ....
020	TS	mg/l................	060	CN	mg/l ....
021	Sv	mg/l................	061	As	mg/l ....
022	Turb	NTU.................	062	Mg	mg/l ....
024	Colour	(pt-Co).............	063	Pb	mg/l ....
025	DO	mg/l................	064	Cu	mg/l ....
027	BOD	mg/l................	065	Zn	mg/l ....
028	PV	mg/l................	066	Cr	mg/l ....
029	COD	mg/l................	067	Cd	mg/l ....
030	NH3 (N)	mg/l................	068	Al	mg/l ....
031	NO2 (N)	mg/l................	070	Ni	mg/l ....
032	NO3 (N)	mg/l................	071	Ag	mg/l ....
033	TKN	mg/l................	072	Si	mg/l ....
035	Alk	mg/l................	073	P	mg/l....................
036	$A\text{-}CO_3$	mg/l................	075	Oil	mg/l ....
037	$A\text{-}HCO_3$	mg/l................	075	Phenol	mg/l ....
038	A-OH	mg/l................	087	Klo-A	mg......................
039	Temp-H	mg/l................	090	Cl.Perf	Nr/100 cc ....
041	T-H	mg/l................	091	Ps.Aer	Nr/100 cc ....
044	$O\text{-}PO_4$	mg/l................	125	T.Coli	Nr/100 cc ....
045	Po_4	mg/l................	126	E.Coli	Nr/100 cc ....
046	SO_4	mg/l	127	F.Strept	Nr/100 cc ....
047	Cl	mg/l................	128	$Col_{22}/7$	Nr/l cc ....
048	Fe	mg/l................	129	$Col_{37}/24$	Nr/l cc ....

chemical properties such as BOD, COD, TSS and metals by titration. The laboratory was also equipped with a gas chromatograph that was dedicated to the DSI lab by a foreign company at the completion of a joint study. Unfortunately, such equipment is often inoperable because of a lack of readily available replacement parts. Although the laboratory equipment was not as sophisticated as that often found in U.S. laboratories, the presence of the chromatograph at the DSI lab provides the first capability to monitor for pollutants on a regular basis. Laboratory personnel indicated that the chromatograph will be used primarily to monitor for the presence of pesticides. The ability to analyze surface and ground water for the presence of pesticides will enable DSI and the General Directorate of Environment to better monitor and protect water resources in the Bursa area.

CONCLUSIONS

Currently, Turkey is at a level of environmental awareness that is primarily based on protecting human health. As an example of this, Curi (pers. com., 1990) expressed surprise that there is sufficient work in the U.S. related to remediating shallow ground water at leaking petroleum storage tank sites to support consulting companies, much less an entire industry of consultants throughout the developed nations such as in the U.S., Canada, Great Britain, France, and Germany.

We conclude that regional perspective leads many countries such as Turkey to consider that it has too many immediate health-based environmental concerns to expend energy and resources on environmental problems that will not immediately affect human health. Turkey cannot afford to inhibit their economic growth by over-regulating their emerging industries, and so, must balance economic growth with prudent environmental controls. That is not to say that governments should give free reign to industry to practice poor housekeeping and to pollute the environment, but should take advantage of the experiences of the United States and other developed countries to successfully manage their environment without suppressing their economic growth.

Education is important to the process of managing the environment in rapidly expanding countries. This includes not only the educational exchange between scientists and regulators of different countries, but also the education of industrial leaders and the general population. By educating the personnel of regulatory agencies, organizations such as UNESCO and related UN agencies, as well as the experienced consulting and engineering firms of industrialized nations, can provide substantial assistance and guidance for environmental management in countries with developing economies. The exchange of information should begin with documentation of technical case histories of subsurface contaminant transport and related hydrogeological investigations to provide the appropriate foundation of knowledge for future studies. Such exchanges would also include regulatory examples of successes and failures as well as providing these countries with health-based limits and standards that have been established over the years by the United States and other countries. Industry leaders also should be educated about the economic advantages of proper environmental management. As many industries in the U.S. are now illustrating, techniques such as waste minimization and spill prevention are proving to be more cost effective than cleaning up large scale contaminant releases that pose significant threats to human health. Many industry leaders now realize the importance of applying good management now to avoid future, more costly cleanups, a realization that didn't begin to impact industries in the U.S. until the mid

1970's. By alerting their industry leaders to the economic advantages of good environmental management, countries with developing economies may avoid unnecessary repetition of earlier poor environmental practices of the U.S. and other industrialized nations.

An example of the importance of the exchange of information is already evident in Turkey. The Regional Director of DSI in Bursa, indicated that some of their regulations concerning the use of ground water are patterned after the United States Bureau of Reclamation and other federal procedures for regulating the utilization of natural resources. By learning about these regulations and applying the best examples to their own resources, Turkish scientists and regulators have learned to manage the utilization of ground water effectively. Such management of ground water is an issue that has yet to be addressed by some states in the U.S.. Therefore, not only may we provide valuable information to Turkey and other countries with developing economies about environmental management, we can also learn from their experiences which serve as microcosms of specific issues and responses.

Finally, as a country situated economically between more industrialized nations and countries with less developed economies, Turkey can make important contributions to such countries. By learning from the successes and failures of the more developed countries, Turkey can avoid repeating mistakes and can develop environmental programs that are best suited to its needs. As some countries reach the level of economic development currently enjoyed by countries such as Turkey, they also will have the opportunity to learn from Turkey's experiences. As more developing countries expand economically, the implementation of effective environmental management programs can become less difficult by following the examples of more experienced countries and by utilizing the full support of industry and government.

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