

Necati Gülbahar
Hatim Elhatip

Estimation of environmental impacts on the water quality of the Tahtalıdam watershed in Izmir, Turkey

Received: 3 August 2004
Accepted: 2 November 2004
Published online: 12 January 2005
© Springer-Verlag 2005

N. Gülbahar
Aksaray Engineering Faculty, Civil
Engineering Department, Niğde University,
68100 Aksaray, Turkey

H. Elhatip (✉)
Aksaray Engineering Faculty, Environ-
mental Engineering Department, Niğde
University, 68100 Aksaray, Turkey
E-mail: hnaim@superonline.com
Tel.: +90-382-2150953
Fax: +90-382-2150592

Abstract Water pollution is a wide-spread problem in different areas of the world. Some of these problems originated from point contamination sources and widespread contaminant outlet sources which are observed in every country. The major elements and chemical loads of surface water have been dominated by constituents derived directly or indirectly from human activities and/or industrial practices that have increased additives in the last several decades. The point sources of contamination may result from the direct wastewater discharges to the dam sites, which are considered to be the most commonly encountered water pollution problems. One of these problems is the eutrophication process which usually occurs in the

static water mass of lakes and other surface water reservoirs. This process may be caused by the continuous increase of nitrogen and phosphorus contents and decrease of O₂ level in water causing an anaerobic condition which may stimulate algae-growth flow in these water bodies, consequently reducing the quality of water. Of course, there are many research methods for determining the various kinds of water pollution. In this research, the hydrochemical parameters were evaluated to estimate the types of pollution sources, the level of pollution, and its environmental impacts on the Tahtalı dam reservoir.

Keywords Contamination sources · Tahtalı dam watershed · Water contamination · Turkey

The Tahtalı dam site and physical properties of the watershed

The Tahtalı dam is in the southwestern part of İzmir city, southwest Turkey (Fig. 1). This dam was constructed to supply about 4,055 l/s of drinking water from the Tahtalı River to İzmir city (Gülbahar 1999). The construction of the Tahtalı dam was completed in 1996. The topographical conditions were suitable for supplying clean water from the reservoir to İzmir city by gravity flow. The maximum reservoir capacity is 307.000 hm³; the minimum capacity is 56.000 hm³ (Kılınç and Gülbahar 1997).

The watershed of the Tahtalı dam covers a surface area of 515 km², extending along the Cuma plain. The

watershed is the water collection area of the Tahtalı River, which runs in the NE–SW direction, through the Cuma plain. About 50% of the area is covered with forests, and 30% of the land is used for agricultural purposes. The remaining is urban area. A general view of the Tahtalı dam site is given in Fig. 2. Other characteristics of the dam are given in Table 1.

Hydrochemical evaluation of the Tahtalı watershed

Human activities near the Tahtalı dam site have had direct and indirect effects on the rates of contamination of surface and groundwater in the Tahtalı watershed area. Direct effects include dissolution and transport of

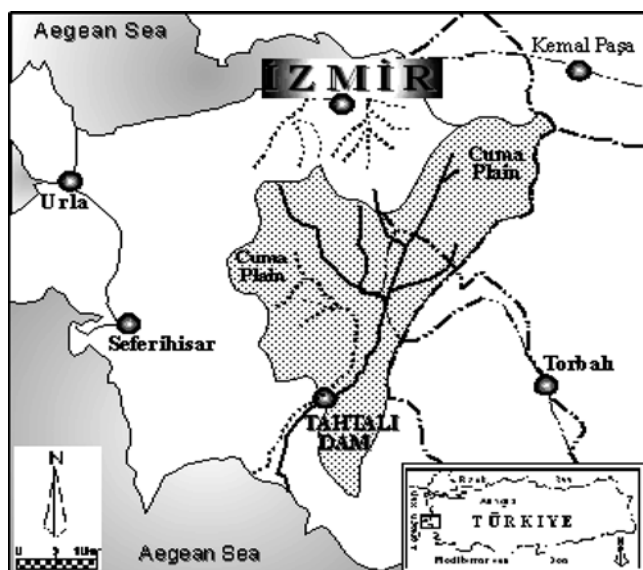


Fig. 1 Location map of the Tahtalı dam site

excess quantities of fertilizers with associated materials and hydrologic alterations related to irrigation and drainage. Indirect effects include changes in water–rock reactions in soils and aquifers caused by increased concentrations of dissolved oxidants, protons, and major ions. Agricultural activities have directly or indirectly affected the concentrations of a large number of inorganic chemicals in groundwater, for example NO_3 , N_2 , Cl , SO_4^{2-} , H^+ , K , Mg , Ca , Fe , Cu , B , Pb , and Zn , as well as a wide variety of pesticides and other organic compounds. For reactive contaminants like NO_3 , it is suggested that a combination of hydrochemical and environmental-tracer analytical approaches might be required to resolve changing inputs from subsequent alterations as causes of concentration gradients in groundwater.



Fig. 2 General view of the Tahtalı dam site

Table 1 Characteristics of the Tahtalı dam in İzmir

Location	İzmir—Turkey
River	Tahtalı
Purpose	Water supply–flood control
Construction (starting and completion) year	1986–1996
Embankment type	Rockfill
Dam volume	2,972,000 m ³
Height (from river bed)	54.50 m
Reservoir volume at normal water surface elevation	306.65 hm ³
Reservoir area at normal water surface elevation	23.52 km ²
Annual domestic water	205 hm ³

The results of hydrochemical analysis are given in Table 2. The main water type of the Tahtalı lake is Ca–Mg–HCO_3 (Fig. 3). The river water type was directly related to the hydro-geochemical properties of the study area. Thus, the high Ca concentration arises from the existing carbonate rocks in the study area.

The Ca/Mg , Ca/Na and $\text{SO}_4^{2-}/\text{Cl}$ ratios, and base change index decreases from the recharge area downwards to the discharge area. Thus, the high concentration of Ca^{+2} and HCO_3 is mainly related to the high CO_2 contents of the marbles. The Tahtalı dam lake is mainly used to provide most of the drinking water for İzmir City. Figure 3 illustrates the variation in temperature, pH and electrical conductivity (EC) values, and concentrations of individual ions in the water samples from the lake. A periodical general uniformity in chemical composition exists, which is related to conditions of sources and rate of recharge of the lake.

Table 2 Hydrochemical analysis of the Tahtalı lake site

Parameters (Units)	1996	1998	2000
$T(^{\circ}\text{C})$	9.4	9.7	8.1
pH	7.7	7.8	8.0
EC ($\mu\text{S/cm}$)	470	510	542
DO (mg/l)	6.6	5.3	4.6
Na (mg/l)	14.0	17.0	19.0
K (mg/l)	5.50	6.0	7.0
Ca (mg/l)	51.00	62.10	70.12
Mg (mg/l)	14.30	15.10	24.30
HCO_3 (mg/l)	303	342	360
SO_4 (mg/l)	16.80	18.30	19.20
Cl (mg/l)	20.90	24.50	24.90
Cu (mg/l)	0.005	0.006	0.008
Fe (mg/l)	0.170	0.223	0.430
Zn (mg/l)	0.014	0.016	0.01
Pb (mg/l)	0.006	0.008	0.020
Cr (mg/l)	0.020	0.037	0.080
B (mg/l)	0.09	0.18	0.42
NO_3 (mg/l)	12.01	16.21	16.65
NO_2 (mg/l)	0.26	0.32	0.50
PO_4 (mg/l)	0.10	0.15	0.19
NH_4 (mg/l)	0.10	0.14	0.17

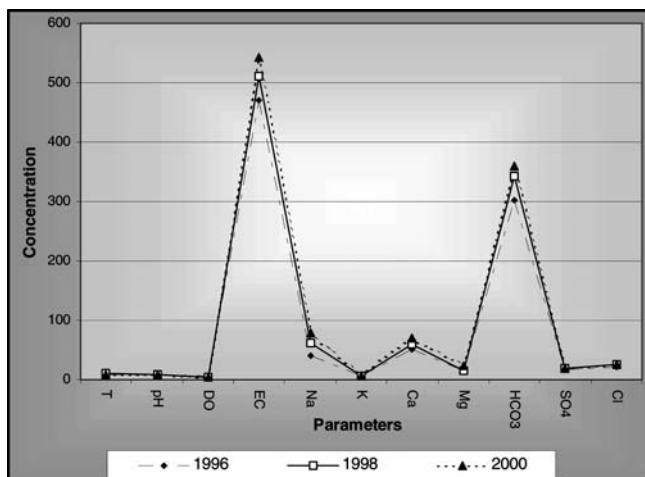


Fig. 3 Physical and chemical parameters of the Tahtali dam lake

The general changes in the EC values of surface water from the research site is periodically compared with the higher ion concentration changes during dry and wet seasons. The results of analysis showed that there has been a significant increase of hydrochemical parameters periodically. The addition of minerals may lead to an increase of EC and NaCl values and cause chemical reactions between the Na and Ca ions during ion exchanges. Also, the high concentrations of most ions in the surface water probably result from surface leaching during irrigation and from contamination by sewage.

Influence of contaminants on water quality of dam site

Use of the word “contamination” is meant to imply that human activities have caused an increase in the flux or concentration of a constituent, but not necessarily that the change has been harmful. The major contaminants considered in this study are N and P, which are the most abundant, mobile, and persistent agricultural contaminants in many surface waters. In addition, agricultural contaminants have caused substantial changes in surface and groundwater geochemistry and water-rock interactions, which have received somewhat less attention. The results of hydrochemical analysis of heavy metals, N, and P, are illustrated in Fig. 4.

The analysis shows that the main sources of nitrate that occurs in the study area include: nitrate from the application of fertilizers in irrigation, and from untreated wastewaters directly discharged to the lake. The common fertilizer applied liberally throughout the irrigation district is $(\text{NH}_4)_2\text{SO}_4$. Through a nitrification process in the presence of oxygen, ammonium is transformed into nitrates according to the following reaction (Freeze and Cherry 1979).

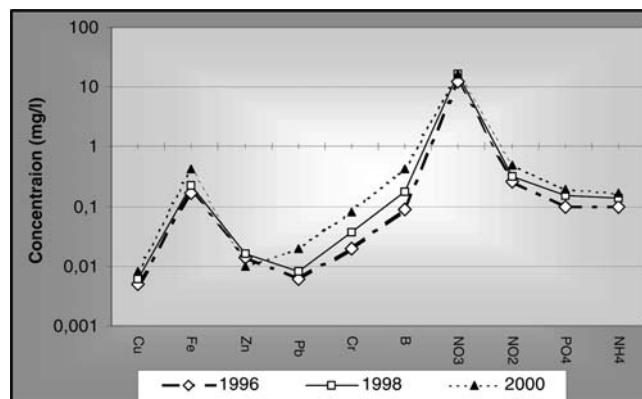


Fig. 4 Changes of heavy metals and nutrients at the dam site



Greater mineralization is generally associated with higher nitrate concentrations of the Tahtali River. The high nitrate concentrations may occur due to the leaching of NO_3 from fertilizers and biocides during irrigation of agricultural land. Leakage from overloaded sewage networks are also sources of NO_3 pollution (Fig. 4). Although the dam was mainly constructed for providing drinking water for İzmir City, the Tahtali River and Lake are highly contaminated by extreme NO_3 , NO_2 , NH_4 and PO_4 loads that originate from irrigation drainage, sewage, and deteriorated septic tanks. Some other inorganic constituents of lake water are present in agricultural additives, including Cl, K, Ca, Mg, and a variety of minor elements .

Agricultural sources of some of these elements can be from local natural sources. Furthermore, agricultural effects on the recharge fluxes of various ions like NO_3 and H^+ can cause changes in weathering rates and ion-exchange equilibrium in the subsurface, thereby altering indirectly the concentrations of other constituents in water (Elhatip et al. 2004). The indirect effects have important implications for geochemical studies of water-rock interactions and can represent sources or sinks for a variety of problematic contaminants such as nutrients and toxic trace elements. Finally, estimating the impacts of human activities on the Tahtali River that recharges the lake for certain uses is important for environmental balance and ecosystems in the study area. The high NO_3 , NH_3 , NH_4 , and PO_4 concentration in the Tahtali dam lake reflects the influences of liquid wastes, high usage of detergents, and the widespread farming and stockbreeding in the research area.

Results and conclusions

This study showed that the Tahtali dam lake is highly contaminated by extreme N–P loading, especially during

dry periods when eutrophication processes usually take place in static water masses. This process usually occurs due to the continuous increase of nitrogen and phosphorus and the decrease of O₂ in the water. This may cause an anaerobic medium and stimulate the algae growth in the lake. Therefore, continuous pollution of the Tahtalı dam reservoirs may consequently reduce the quality of the lake. Common agricultural practices have caused substantial increases in groundwater recharge fluxes and concentrations of major elements and a variety of other heavy metals. These increases have resulted in a transient agricultural chemical signal in aquifers that have groundwater residence times of decades or more.

Some elements are added to the hydrosphere directly as components of fertilizers or other additives. Some are associated indirectly with fertilizer loadings or land disturbance through enhanced rates of leaching of natural sources in soils. This leads to physical and biolog-

ical changes and to increased acidity or ionic strength of agricultural recharge. In addition, high fluxes of NH₄ and NO₃ in recharging groundwater have resulted in unnaturally high concentrations of chemical species released from aquifer materials by oxidation reactions in the saturated zone, because the electron demand of NO₃ in agriculturally contaminated recharge is commonly several times higher than that of dissolved O₂ in uncontaminated recharge.

In cases of increasing N and P loads being greater than normal conditions, dramatic quality changes will occur in the water mass. Moreover, identifying the quality and quantity of water pollutants originating from non-point sources for solving water pollution questions, is a difficult and complex problem. Therefore, the only real solution to the environmental impacts of pollution is the determination of protection zones and implementation of good land use planning to to maintain control of the activities in watersheds.

References

- Elhatip H, Afsin M, Kuşçu İ, Dirik K, Kurmaç Y, Kavurmacı M (2004) Influences of human activities and agriculture on groundwater quality of Kayseri-Incesu-Dokuzpınar springs, Central Anatolian part of Turkey. *Environ Geol* 44(4):490–494
- Freeze RA, Cherry JA (1979) *Groundwater*. Prentice-Hall, Englewood Cliffs, p 553
- Güslbahar N (1999) İzmir Tahtalı Barajı Su Toplama Havzasında Koruma ve Kullanma Dengesi, Doktora Tezi, DPU Fen Bilimleri Enstitüsü, Kütahya
- Kılınç MY, Gülbahar N (1997) The balanced multiple use and protection of watershed resources, through integrated watershed management for sustainable development. In: XI world forestry congress, 12–22 October, Antalya, Turkey, p 19