Environmental Geology (1995) 25: 109–113


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# Environmental contamination of groundwater in the Gaza Strip

Received: 12 April 1994 / Accepted: 26 June 1994

**Abstract** Environmental problems of groundwater contamination in the Gaza Strip are summarized in this paper. The Gaza Strip is a very narrow and highly populated area along the coast of the Mediterranean Sea (360 $km^2$). Human activities greatly threaten the groundwater resources in the area, while the unconfined nature of some parts of the coastal main aquifer favors groundwater contamination. Recent investigations show contamination of the aquifer with organic substances from detergents, agrochemicals, sewage (cesspools), and waste degradation. These effects enhance each other because there is no recycling industry, sewage system, or any type of environmental protection management at present. Inorganic contamination results from overpumping, which increases the salinity of the groundwater. Seawater intrusion also increases the salinity of the groundwater that are used for drinking and agricultural purposes. Consequently, at present about 80 percent of the groundwater in the Gaza Strip is unfit for both human and animal consumption. Solutions are very urgently needed for these problems in order to prevent the spread of dangerous diseases.

**Key words** Gaza Strip · West Bank · Groundwater · Hydrogeology · Hydrology · Environmental pollution · Contamination · Middle East

## Introduction

The Gaza Strip is a heavily populated (850,000 people), very narrow area along the eastern coast of the Mediterranean Sea (360 $km^2$), with one of the highest population densities in the world. The present water situation in the Gaza Strip includes two major aspects: groundwater contamination of the main aquifer and shortage of groundwater. This aquifer is recharged from several sources, which include rainwater, sewage, irrigation, and seawater intrusion. The estimated shortfall was about 50 $Mm^3$ (million cubic meter) in 1992, and it is expected to increase annually due to further increases in population density.

The Gaza Strip is located in an arid to semiarid region. The annual total precipitation ranges from 200 to 400 mm, with an average of about 300 mm. The south is bordered by the Sinai Desert, the east by the Naqab Desert, and the west by the Mediterranean Sea (Fig. 1). The coastal 1- to 2-km-wide belt along the Mediterranean Sea is covered with sand dunes about 20–40 m above sea level. These sand dunes are composed mainly of friable white sand and contain minor amounts of carbonate shell fragments. Quartz and feldspars are the major mineral components. Most of the Gaza Strip is covered by Quaternary soil, with clayey material increasing towards the east. Clay minerals in soils can absorb many chemicals, including both organics and inorganics, and have partially alleviated the extent of groundwater contamination in the Gaza Strip for a long time.

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## Geological and hydrogeological background

Inspite of the severe water crisis in the Gaza Strip, the geology and hydrogeology are poorly studied and described. This is due to the lack of specialists, equipment, and the political situation since the 1967 war.

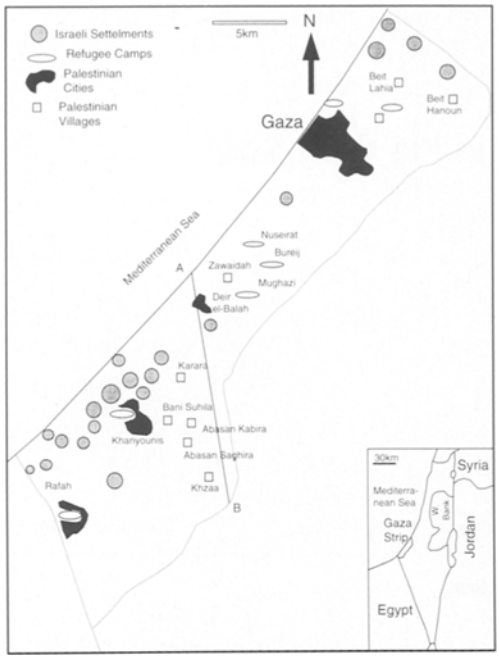


**Fig. 1** Location map of the Gaza Strip

## Coastal Pleistocene aquifer

The Pleistocene coastal aquifer, composed of marine sands and sandstones, is the main aquifer in the Gaza Strip. The sandstones are mainly composed of medium to coarse sand grains (mostly quartz and rare feldspars and carbonate shell fragments) partially cemented by calcite in the form of sparite.

The aquifer is divided into several subaquifers (A, B, C, and D) along the Mediterranean coast (Fig. 2). Impermeable clayey and silty layers—usually of continental deposits and paleosols—define the subaquifers. The clayey layers represent unconformities or breaks in sedimentation, at times of sea regression. Towards the east, these clayey lenses wedge out and disappear gradually, with the formation of a single aquifer with a thickness of 100–180 m. The average thickness of the aquifer is about 150 m; in the east (near the border and beyond) the thickness of this aquifer is reduced to 80–100 m. The base of the coastal aquifer system is formed of a series of impermeable black shales of Neogene age (Sakiye Formation).

Groundwater in this aquifer is of medium to poor quality and is characterized by medium to high salinity. Only small parts of the aquifer—in the vicinity of the Israeli settlements—have good water quality. The only groundwater extracted in the area derives from the shallow coastal aquifer. Some 2000 wells penetrate this aquifer up to a maximum depth of 60–80 m, generally tapping only the uppermost layer, which contains the medium-quality waters.

Groundwater is the only water source in the Gaza Strip. The entire population of the area depends upon groundwater as its primary source for drinking, agricultural, and domestic water supplies. Two small valleys (Gaza and Salqah valleys) cross the Gaza Strip from east to west but have little water in winter and are dry in summer. Before 1967, flooding in the Gaza Valley caused the closure of the main Gaza motorway for few days each year. However, at the present time, the Gaza Valley is almost dry in winter. This is due to the construction of small dams to stop the water flow from east to west by the Israelis (Abu-Mailah 1992) beyond the border. The water shortage in the Gaza Strip of about 50 $Mm^3$ in 1992 is expected to increase by the year 2000. The water situation in the Gaza Strip is critical, according to Kally (1991), due to the very high pumping rate from the groundwater reservoirs. According to Roy (1986), the annual amounts of water irrigation used for in 1984 were 123 $m^3$ per Palestinian and 2326 $m^3$ per Israeli.

Since no thorough studies have been done regarding the groundwater contamination in the Gaza Strip, the author summarizes here the extent of groundwater contamination in the area by focusing on several issues. The data presented here rely mostly on field observations by the author during the last eight years and to some extent on published literature. Another aim of this preliminary paper on the groundwater environmental pollution in the Gaza Strip is to open the door for more comprehensive research in this area.

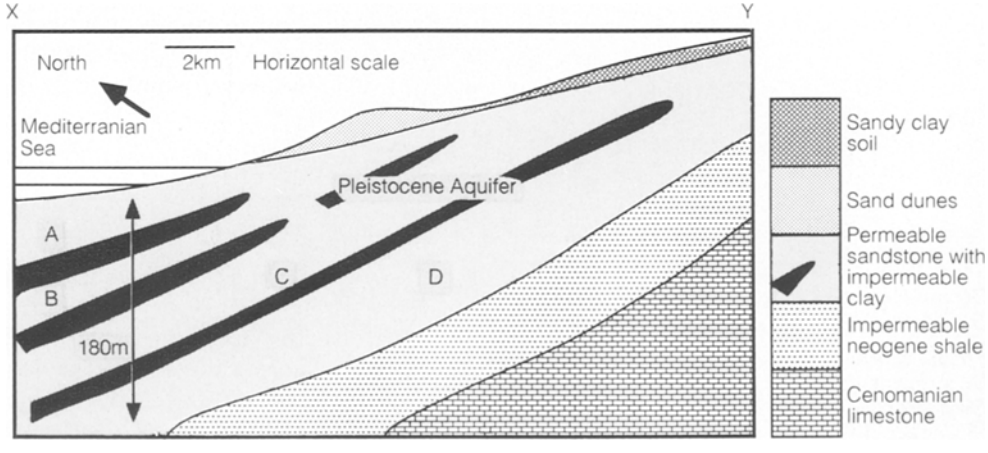


**Fig. 2** Hydrogeological cross section across the Gaza Strip