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Chemical and microbiological quality of desalinated water, groundwater and rain-fed cisterns in the Gaza strip, Palestine

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ABSTRACT

The aim of this study was to assess the physiochemical and microbiological quality of the domestic water through one-year long surveillance in Gaza Strip, Palestine. Water samples were taken from rain-fed cisterns, groundwater from the water network, and desalinated water. For certain chemical parameters, such as nitrate, a high percentage of water samples from all sources exceeded the limits of the Palestinian Standard Institution and the World Health Organization (WHO). Total dissolved solid (TDS) readings were non-compliant for most samples from groundwater and water from rain-fed cisterns, but the TDS quality was far better in desalinated water. As far as microbiological quality is concerned, high percentages of non-compliance were observed for total *Coliform* and fecal *Coliform* in most water samples, which was also reflected by the high incidence of water-borne diseases in Gaza Strip. The study reveals a clear superiority of quality for desalinated water, but also the need to adopt better practices (maintenance and pre- and post-treatment) in the desalination plants.

1. Introduction

With the pollution of water caused by human activities, serious health problems and other economic costs related to water treatment, remediation and locating a new water supply, become evident [1]. In the Middle East, the increasing deterioration in quality of available water and water deficiency are looming, while in the Palestinian context the problems of both water deficiency and contamination are obvious and acute [2–4]. Water could be chemically, physically, or microbiologically contaminated. Each of which is linked to various sources and health related problems and consequences. Two main factors determine the chemical and microbiological composition of water quality: artificial and natural contamination. Any microbiological or chemical analysis of water reveals the joint effects of both sources of contamination, and it is usually impossible to fully identify and separate these sources [5].

The main source of microbiological contamination is microorganisms from human or animal excreta, which reaches humans through contaminated water from wastewater, landfills, or wastewater treatment stations, causing serious health problems. For example, according to the UN, diarrhea accounts for 80% of all diseases and over one third of deaths in developing countries, which are caused by the patients' consumption of contaminated water [1,5]. Most of the gastrointestinal infections that may be transmitted through drinking water are transmitted via fecal–oral pathway [6]. Hence, the effects of improvements in the quality of water were felt on the combat against endemic diseases such as typhoid and cholera in adults, and diarrhea in children [7]. The most commonly used indicators for microbiological contamination are the *Coliforms*: total and fecal *Coliforms*. *E. coli* is a subgroup of total *Coliform* group [8]. Detection of bacterial indicators in drinking water signifies the presence of pathogenic organisms that are the source of water-borne diseases.

Chemical pollution, the other type of water contamination, could be organic or inorganic. Organic chemicals include leachate (e.g., from solid waste), synthetic organic compounds, and chlorinated compounds like Trihalomethans (THM), which are associated with poisoning, cancer, liver, kidney and Central Nervous System problems. Inorganic compounds, on the other hand, consist of substances resulting from water treatment and pesticides or pollution resulting from industry (e.g.: Cd, Ba, Hg, Mo and B). Many diseases are associated with these elements including, poisoning, cancer, hypertension and infantile cyanosis. The latter is associated with nitrate toxicity [8].

Various sources are suspected of causing water pollution in the Gaza Strip, Palestine. These primarily include wastewater, overuse of fertilizers and agricultural pesticides, and solid waste that might produce toxic substance, e.g. nitrate [3,4]. The aim of this study was to shed light on drinking water quality in Gaza Strip. Different sources of water, including desalinated water, groundwater, and harvested rainwater were studied and water related problems were assessed in terms of potential sources of water pollution, and the impact of water pollution on the health of the inhabitants of Gaza Strip.

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2. Material and methods

2.1. Study area

The Gaza Strip area is part of Palestine. It is a small area of about 365 km^2 located at the eastern coast of the Mediterranean, about 35 km long and between 6 and 12 km wide (Fig. 1) The Gaza Strip forms a transitional zone between the semi-humid coastal area in the north and the semi-arid Sinai desert in the south. The area consists of a littoral zone, a strip of dunes from the Quaternary era situated on the top of a system of older Pleistocene beach ridge, and more to the east, gently sloping alluvial and loess plains [9]. The total population of GS was 1,202,756 persons in 2004 as extrapolated from the data of 1997 census by the Palestinian Central Bureau of Statistics [10].

The three sources of domestic water supply in Gaza Strip are 1) groundwater from the coastal aquifer, 2) desalinated water utilizing brackish and, less commonly, seawater as feed, and 3) rainwater harvesting wells [11–14]. Groundwater from the coastal aquifer supplies the Strip with 90% of its domestic (i.e., municipal and agricultural) water needs [11]. The aquifer in the Gaza Strip is part of the coastal aquifer, which extends from Mt. Carmel in the north to the Sinai desert in the south with a variable width and depth. The total area of the coastal aquifer is about 2000 km^2 with 400 km^2 beneath the Gaza Strip [15]. The aquifer media are composed mainly of alluvial sandstone with gravel from the Tertiary era covered with Quaternary sand dunes. These dunes extend along the shoreline up to few kilometers inland. The depth of the aquifer varies from about 170 m at the shoreline to a few meters at the eastern boundary (Fig. 2). This makes it vulnerable for pollutants mainly from untreated wastewater in the area [3,11,12]. There is a very thick impermeable clay layer underneath the aquifer, the Saqiya formation. This 400 to 1000 m layer forms the bed of the aquifer. Some clay layers of different thicknesses up to 20 m divide the aquifer into three main sub-aquifers. These sub-aquifers were classified into sub-aquifer A, which is at the top; sub-aquifer B; and sub-aquifer C beneath (Fig. 2) [9].

Salinity of the coastal aquifer's groundwater has been constantly increasing over time, due to seawater intrusion and the excessive withdrawal of water, far exceeding the natural recharge [11,12]. In many areas of the Gaza Strip, salinity in groundwater extracted from the aquifer has exceeded 1000 mg/L, and even 3000 mg/L in some

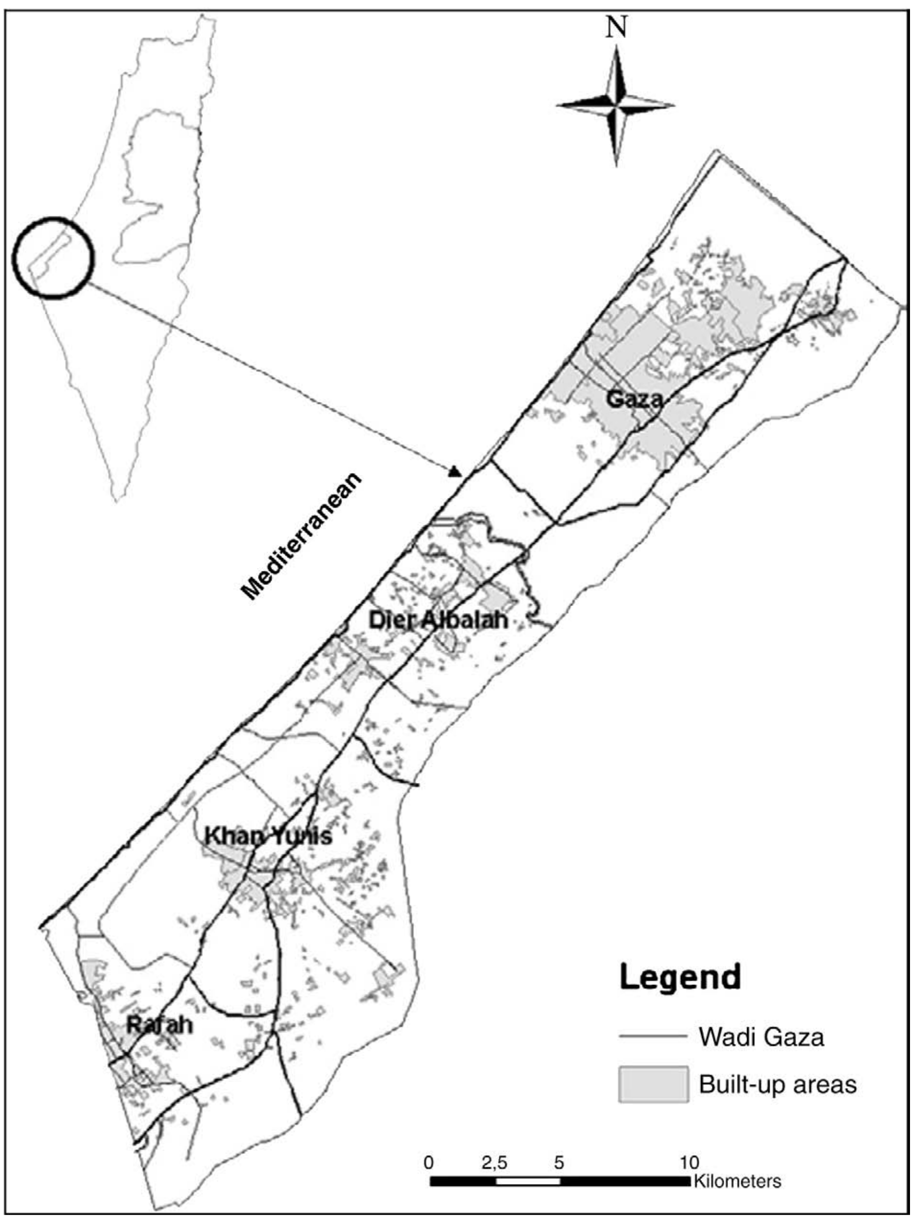

Fig. 1. Location map of the Gaza Strip.