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Research Paper

Management of waste water discharge within the Nile Valley of Egypt: The collapse of Al Ballanah waste water's lake in Aswan in September 2013

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ABSTRACT

This paper investigates the management strategies of waste water being conveyed into the hinterland of the Nile Valley areas in south Egypt. The inappropriate planning for sanitation drainage and treatment localities and consequent waste water use has developed an environmental disaster. The surplus accumulation of waste water into the evaporation lake led to its collapse in September 2013, and the flows contaminated the agricultural areas and the Nile River. Remote sensing data, digital elevation models (DEM) and soil maps were integrated into geographic information system (GIS) to ensure the full consumption of waste water via evaporation and cultivation of appropriate non-edible crops. The annual produced treated-water is approximately 10 million cubic meters, and the existing cultivated woodland covers 140 ha, which only consumes 1.1 million cubic meters of water. The oxidation and evaporation lakes and ponds annually consume 4 million cubic meters. The available soil suitable for reclamation is distributed within higher topography areas that require pumping via pressure lines. These soils cover 554.6 h and would consume up to 10.5 million cubic meters, which is sufficient to consume the treated water. Given the current difficulties to cultivate the available soil, the surplus accumulation of waste water can further be consumed via increasing evaporation rates from the water bodies through the introduction of voracious water crops such as water hyacinth. Additionally, these water plants will enhance the quality of waste water and could be used as raw materials for other purposes.

1. Introduction

Countries in the drylands are facing major challenges to better manage and use its water resources and to increase the inhabited territory on the expense of its vast desert (Faid et al., 2003). The management of water resources such as rivers, groundwater and catchments are of great environmental, economic and political importance for all dryland countries (Tooth, 2000). Generally, the hydrological measurements and observations of the dryland remain sporadic and insufficient to draw a detailed description of the processes (Wade et al., 2010). Therefore, the hydrological processes are not fully understood and the hydrological models are uncalibrated (El Bastawesy et al., 2009). Since the early days of history, the anthropogenic activities in the dryland have been depending on the local abundance of some water resources. This shortage of water supplies is being supplemented by tapping deep groundwater, desalination, conveyance from distant sources such as the Great Man-Made River in Libya, and Tushka project in Egypt (El Bastawesy et al., 2013). In turn, severe geo-environmental problems were shortly appeared after establishment of the unprecedented large-scale development projects, due to the lack of understanding of the hydrological processes within dryland catchments.

Wastewater disposal is becoming a problem in developing countries as large quantities of municipal waste and industrial effluent are being produced due to increased urbanization and industrialization respectively (Alloway and Ayres, 1997). The major challenge is how to deal with the waste which is being released at a rate faster than its proper disposal (Masona et al., 2011). The long term use of wastewater in agricultural land is

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resulting in the contamination of soils by heavy metals. These heavy metals include zinc (Zn), cadmium (Cd), copper (Cu), nickel (Ni), lead (Pb), manganese (Mn), iron (Fe), mercury (Hg) and chromium (Cr) (Dougherty and Hall, 1995). Though most heavy metals are needed in trace amounts by growing plants, their excess can result in plant intoxication. The occurrence of heavy metals in industrial wastewater is of interest because they are often present at significant levels and if discharged into surface waters can have severe effects on the environment and public health. Thus the presence of high heavy metal concentrations in plant tissues brings about poisoning problems in human beings and other animals feeding on specific plant tissues. Therefore, irrigation with wastewater needs careful and planned management to ameliorate the negative impacts that may arise.

Unfortunately, one of the options for dealing with wastewater is to use it in agricultural land not only to disposing it, but the limited availability of surface and groundwater resources encouraged the locals to use the contaminated water from the alluvium aquifers for irrigation. For instance, the measured annual discharge of different treatment facilities across Saudi Arabia exceeded 700 million cubic meters, and around 217 million cubic meters of this water were used for irrigation (Al-Mogrin, 2001). In Egypt, large quantities of waste-discharge are being accumulated in large oxidation pools and retention dykes in the desert hinterland. In September 2013 one of these newly developed ponds of waste water in Aswan Governorate south of Egypt has resulted into torrents of waste water swept the areas downstream and contaminated the irrigation channels and the fields. The interaction of catchment hydrological processes and the inadequate management for waste water must be investigated to minimise the negative environmental impact. Therefore, this paper aims to develop a distributed water-balance model to fully consume the annual yield delivered to Al Ballanah waste water system. This aim will be achieved through the integration of remote sensing, ancillary data, and field work into GIS. The specific objectives are: 1) Delineating the drainage networks of Wadi Al Rukbah from the DEM. 2) Estimating the available arable soil and its distribution within the catchment and nearby areas. 3) Estimating the annual evaporation loss from the water bodies, and the required water for existing and proposed woodland. 4) Determination of impact of flash flooding on the area, and the required mitigation measures.

2. The study area

The floor of Kom Ombo graben stretches east-west for approximately 80 km in the south eastern desert of Egypt. Topographically, the graben floor descends from 250 m above sea level in the east (a.s.l) to 85 m a.s.l at the Nile River in the west (Fig. 1). The graben can be subdivided into two parts being partially separated by a protruding hill in middle of it. The western part is termed ‘‘Kom Ombo trough”, and the eastern part is known as ‘‘Al Nuqrah plain” ((Embabi, 2004; Said, 1981). Additionally, the irrigation channels from the Nile are equipped by several pumping stations to convey water eastward against the main slope of Kom Ombo trough and Al Nuqrah plains (El Bastawesy et al., 2010).

The study area gains a particular importance as 43 villages have been built in it for the Nubians who abandoned their original villages following the completion of Aswan High Dam in 1969 (Fig. 2A). The newly build Nubian villages in the area kept the original names of those flooded by Lake Nasser. The southern plateau flanking Kom Ombo graben is marked by steep cliffs from the west,

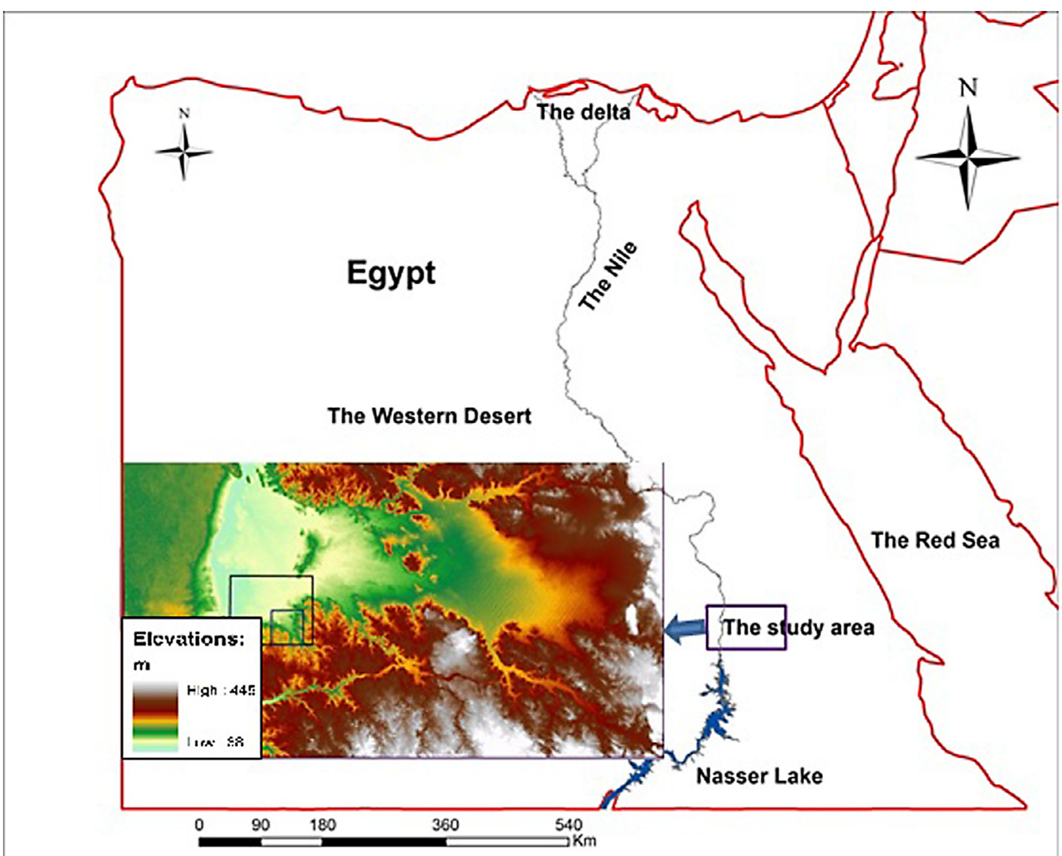

Fig. 1. Location map of the study area, the displayed elevations are derived from the SRTM data (http://glovis.usgs.gov/ and the solid outlines refer to locations of the inset Figs. 2, 4 and 6–8.