SURFACE WATER POLLUTION AND ITS EFFECT ON GROUNDWATER IN TAIZ WATER BASIN.

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ABSTRACT:

Taiz basin is a part of upper W.Rasyan catchment including Taiz City, it is a highlands and nearly closed basin of some 600 km^2 with a population of about 0.75 millions. The population growth, municipal and industrial activities in the city have resulted in increasing deterioration of water quality especially in the shallow groundwater aquifer which represents the principal groundwater resource in the area. Into the basin system, nearly 5 million cubic meters per year of untreated wastewater discharged through the septic tanks, stream channels, sewage lagoons and industrial bonds.

In the present study the main pollution sources and their effect on the groundwater, in shallow alluvial and fracture volcanic aquifers in Taiz basin area, have been investigated throughout the identification of TDS, Major ions, some heavy metals, nitrate, BOD, COD and bacteriological parameters. Laboratory analysis of the water samples from the existing wells near and beneath the contaminant sources show that the surface pollutants have seriously affected the groundwater, e.g. the water constituent of the groundwater samples from Hawgala, Hawban and Hidran areas exceed by many times the WHO standards limits for drinking and irrigation uses and the groundwater in these areas become harmful not only for human but also for soils and plants.

The study recommended that the surface water and groundwater system should be protected and restored, construction of treatment plant for municipal and industrial waste water, rebuilding sewage system for the city, enforced watershed protection regulation, and the water supply from Hawban and Hawgala wells must be treated before mixing with fresh water from Hayma and the city wells.

Key words: Taiz basin, groundwater, contamination.

1. INTRODUCTION:

Taiz area is faced with water shortage and dramatic decrease in water quality. These threaten, principally, the shallow alluvial aquifer which represents the main renewable water sources to the people. Groundwater protection against contamination requires hydrochemical investigations, more extensive water management and treatment strategies. The approach proposed in this study combines hydrogeological and Hydrochemical studies. Extensive field measurements were conducted, chemical and microbiological analysis for selected water samples were made and integrated for evaluation of the groundwater quality, and determination the impacts of waste-water disposal sites on the groundwater in the alluvial and to some extent in the fracture volcanic aquifer the Wadis below the contaminant sources.

2. THE STUDY AREA:

2.1. Location

Taiz basin (Taizziya area) is occupied in the upper part of W.Rasyan catchment in the western Yemen Mountains, it extends between the latitudes 13º 34' and 13º 47' North, and the longitudes 43º 48' and 44º 12' East. The basin is densely populated and includes Taiz City which represented the third largest and important cities in Yemen (Fig.1).

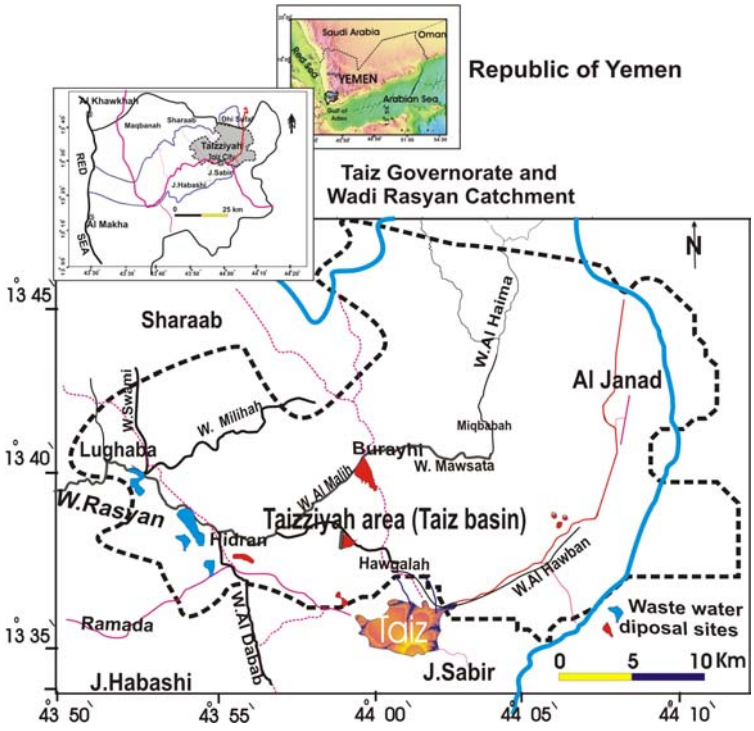

Figure.1. Location map of Taizziyah area showing some waste water disposal sites.

2.2. Physiography and Climate

The study area extends west east for about 30 Km from the east of Ramada into the eastern water divide (Al Janad plateua) (Fig.2), it's bounded by Dhisufal mountains in the north and by J.Sabir and J.Habashi in the south. It ranges in elevation between 900 m in the west at Lughabah to about 1450 m at the eastern border. The topography of the area is characterized in general by rolling hills with numerous small streams; there are some green valleys (W.Al Hayma and W.Hawban) with dense vegetation, scattered long trees in the valleys bottom. The water drain from the north and south towards the basin center (Hidran) where it form a large wetland. The drainage pattern of the investigated area are classified as dendritic to sub-dendritic with characteristics of a volcanic terrain controlled to the same extent by geologic structure (A. Abdulqader,2005). Taiz City is located at the northern down slope of J.Saber at 1200-1300 m above mean sea level (amsl). The drainage pattern and topographic counters were illustrated in Figure.2.

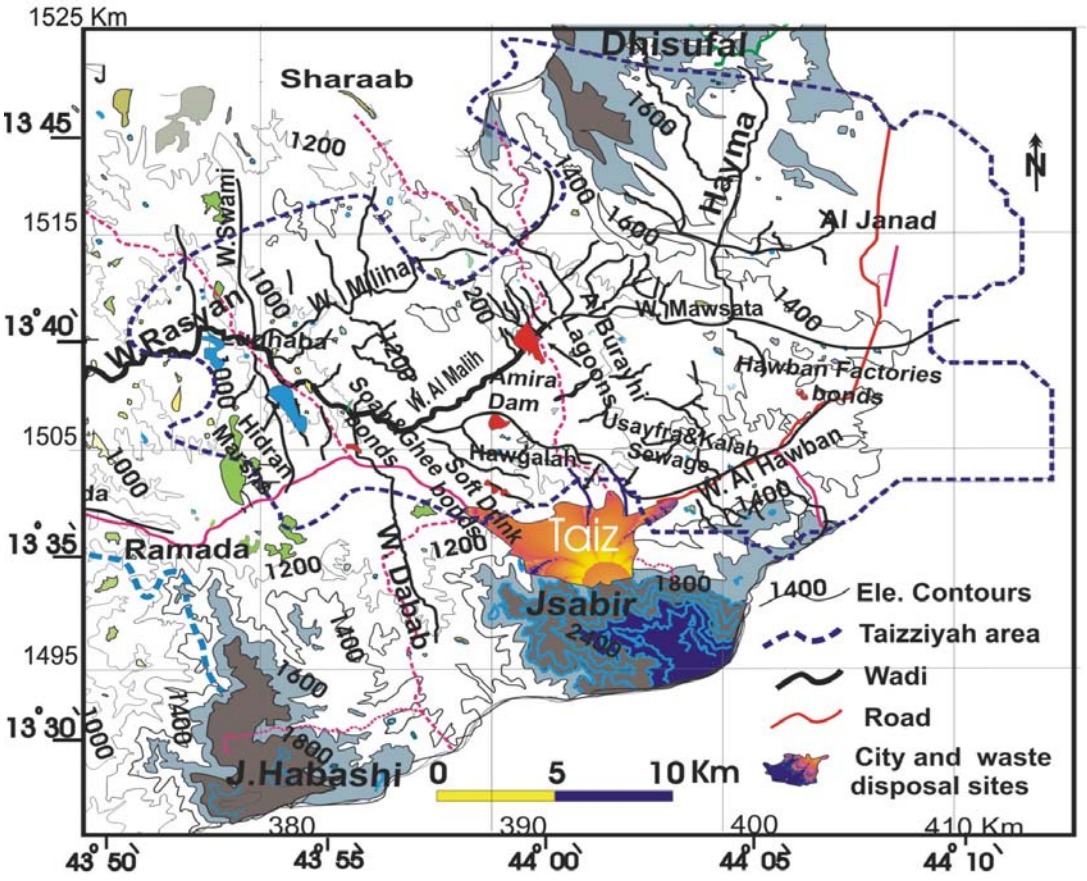

Figure.2. Topgraphic contours, drainage lines and waste water disposal sites in Taiz basin.

The climate of the area is characterized by a semi-arid type, where annual precipitation significantly less than natural losses by evapotranspiration. The average

maximum temperatures are (25- 34 ºC), the mean monthly relative humidity is ranging between 47- 60 %, and the area is exposed to north westerly and south westerly winds. The mean annual rainfall is about 540 mm (A. Abdulqader, 2005). The wettest month of the year is Sebtamber, which has a normal rainfall of 120 mm. The driest month of the year is December, which has a normal rainfall of < 15 mm. Most of precipitation occurs in convective storms of high intensity and limited duration. The annual total evapotranspiration ranges between 1790-2000 mm (as calculated by many workers and organizations, e.g. LBG, 1977; DHV,1983; TS-HWC,1992; Gun and Ahmed,1995 and DEY,1997).

2.3. Geology

The geological map and geological cross-section (Fig.3) were derived from the geological map of the Republic of Yemen at scale 1:250,000 "sheet Taiz" (Kruck and Schäffer., 1991) and the Geological map of Taiz scale 1:100,000 (NWRA., 1997).

Tawila Sandstone (Cretaceous) is the oldest rock unit in the study area. It outcrops in the western part of the area as isolated blocks of about 340 m thick and extensively jointed in various trends. The Tertiary volcanics are the dominant rock units in the area, made of sequences of basic and acidic lavas, fissure eruption and pyroclastics with sedimentary intercalations. They are begin with a lower basic facies (Tb1) followed by an acidic facies (Tr1) then middle basic volcanics (Tb2) followed by a second acidic facies (Tr2), then the upper basic facies (Tb3) followed by the upper acidic facies (Tr3) (Kruck et al., 1996). Granite plutons of J.Sabir and J.Habashi (late Miocene) were intruded in the south. The total thickness of volcanic sequences is assumed to be from a few hundred to perhaps as much as 2000 m with the oldest absolute ages of about 30 Ma (Civeta et al., 1978, Capaldi, et al., 1983). Quaternary loose sediments and recent alluvial deposits which cover Al Janad plateau and fill the wadi courses are consisting of gravels, sands, silts and clay with with a thickness that varies from 5–50 m.

Structurally, Taiz basin is located in an east-west faulted graben of 25 km wide bounded by Habir fault from the north and Taiz-Ramada fault from the south. The eastern edge of the graben is occupied by a flat loose covered plateau (Al Janad plateau) and bounded by middle mountain range from the west. It is covered by volcanic rocks with a thin cover of Alluvial deposits in the wadis. The main faults trends are NNW-SSE, NW and NE, it's affected also by large number of dykes and volcanic intrusions.

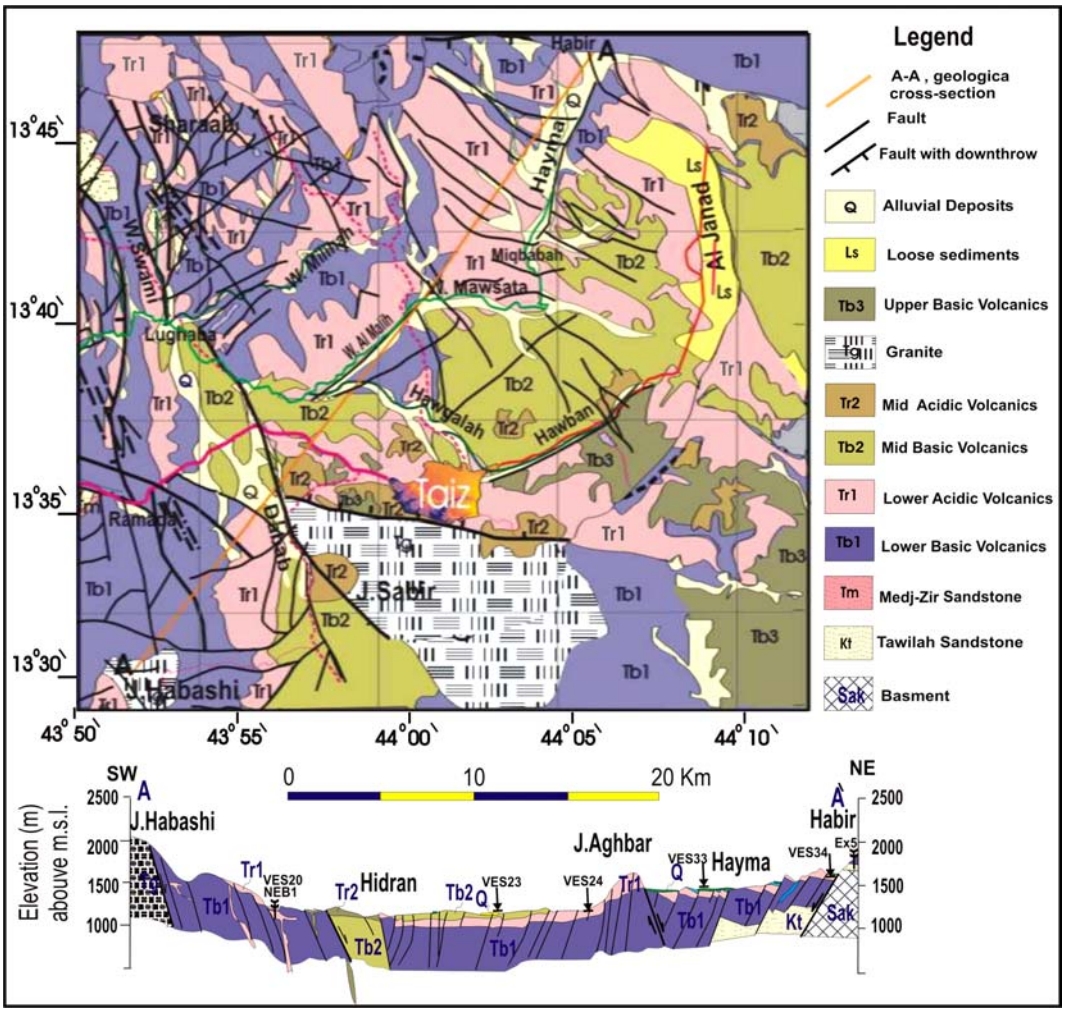

Figure.3. Geological map of Taizziyah area, Taiz, Yemen.

3. HYDRAULIC SITUATION:

The hydrogeology of the region has not been studied in detail and knowledge is limited to a few investigations describing the regional hydrogeology, of the W.Rasyan, the most important are GIBB, (1977); DHV, (1983) and TS-HWC, (1992). Other local investigations were concentrated on the vicinity of Taiz and focused on the shallow alluvial aquifer such as JMM, (1974); HSE&LBG, (1976); Duby, (1992 and 1996). The only one comprehensive study was carried out by DEY, (1997) flowed by hydrochemical study on the upper W.Rasyan (Welle J. van der., 1997). In the present study, the hydrological situation of the area is discussed through the identification of the surface water features and groundwater systems.

3.1. Surface Water System

The main surface water features are the waste water discharge bonds such as Burayhi sewage lagoons, Ameria dam, Ussaifra and Kalaba sewage channels, and Hidran wet lands. These points receive an influx of water and probably act as localized recharge sites to the groundwater system; they used also to convey water for irrigation and livestock in drought seasons;

Precipitation is the main source of recharge to the ground water, rainfall over the mountainous areas drains into Taiz plain and towards the main stream of W.Rasyan. Runoff also percolates downward through the joints, fissures, fractures, and cavities in the volcanic rocks. The area receives about 300 Mm^3/yr of rainfall, most of this amount is consumed by irrigation, evapotranspiration and reservoir evaporation, the remnant may recharge into the subsurface. The total annual runoff in Taizziyah is estimated about 11.25 Mm^3, and the quantity of groundwater recharge is estimated about 17.5 Mm^3/yr (0.05 of direct rainfall and 0.2 of runoff quantity).

3.2. Groundwater System

The groundwater system in the study area consists of three aquifers; 1) The Quaternary to Recent (alluvial deposits), Tertiary (fracture volcanic rocks) and Cretaceous (Tawila Sandstone) (Fig.4 and 5). Alluvial aquifer is the main exploited groundwater aquifer, composed of flood deposits including gravels, sands, silts and clay. This aquifer constitutes the shallow upper-most layer filling the wadis, the thickness of the aquifer ranges between 5 m and 50 m, the depth to water table is less than 7 m in Hawgala and Hidran areas but at greater depths (7 -25 m) in Hawban and Hayma area due to over abstraction. Its groundwater occurs in unconfined condition, the transmisivity (T) varies from 88 m^2/d and 1489 m^2/d with hydraulic conductivity (k) between 2.2 and 57 m/d. The wells drilled in this unit have variable yields (5 -13.5 l/s), and its storage coefficient ranged between 1.20E-07 and 0.041 (A.Abdulqader, 2005).

The fracture volcanic is represented the second hydrogeological unit in the study area, the aquifer comprises a thick sequence (70 m and 400 m) of fractured basic and acidic lavas intercalated with tuffs, ash and pyroclasts. Its groundwater occurs under confined to semi-confined conditions. Pyroclastic rocks have the highest tarnsmisivity

(14-105 m^2/d), while, the fractured basalts have the lowest values (4.6-18 m^2/d) depending on fracture intensity.

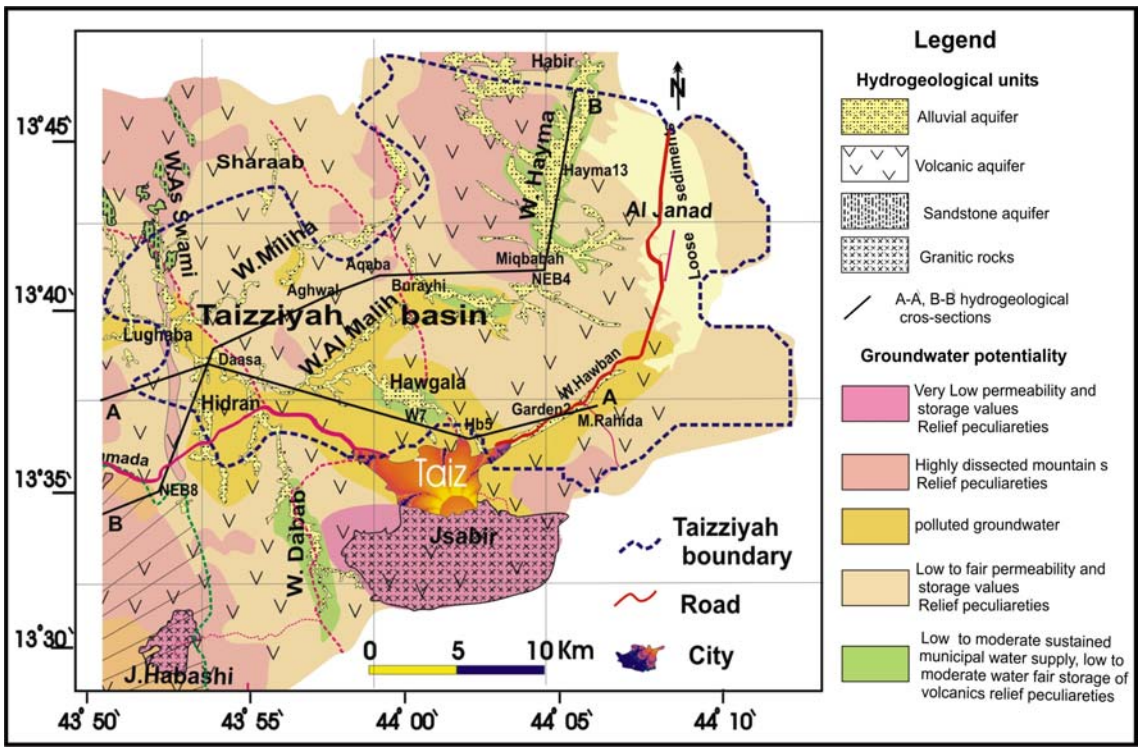

Figure. 4. Groundwater potential map of Taiz Basin.

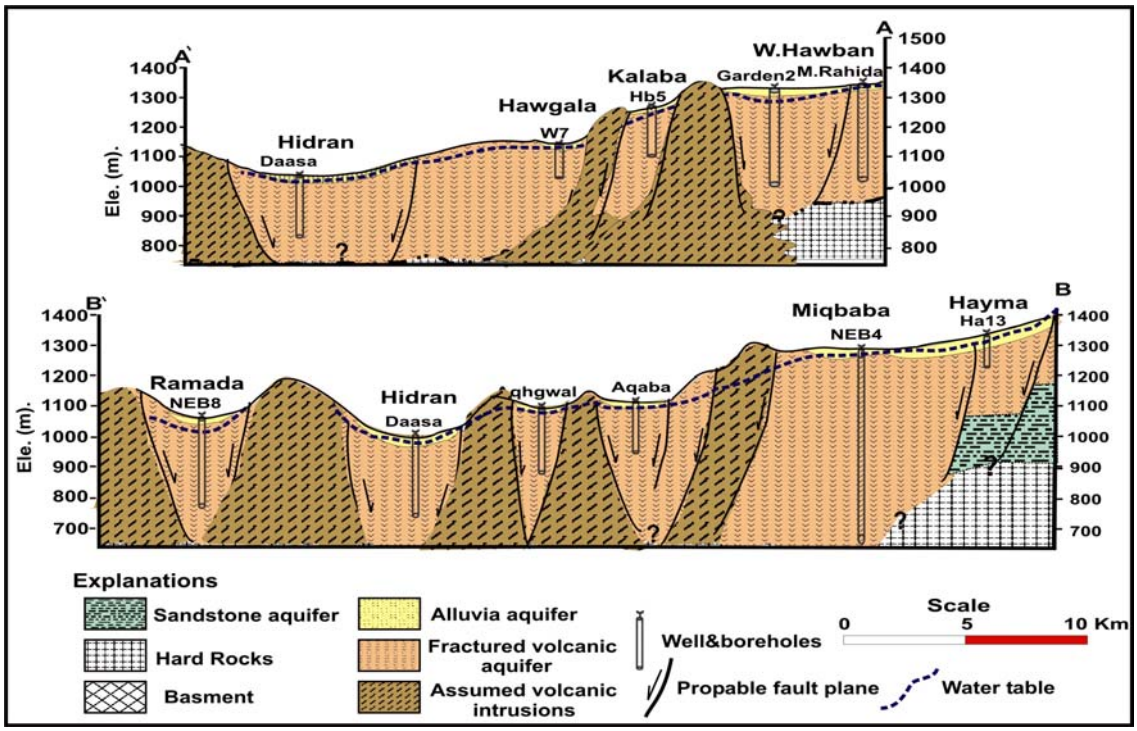

Figure.5. Hydrogeological cross-section along the profiles; a) between Hayma to Hawban and, b) between Hawban and North of Ramada.

The hydraulic conductivity of the fracture volcanic aquifer is ranging between 0.03 to 0.7 m/d. The wells drilled fracture basalt aquifer ranged in yields between 4 to 8 l/s and may reach to about 17 l/s in pyroclasts and tuffs. Although its low storage, this unit can be considered adequate as an aquifer to supply the city of Taiz, due to its wide spread, and the probability of intersecting significant fracture conduits.

The sandstone aquifer crops out in the western part of the basin and detected at depth of about 388 m in upper W.Al Hayma with total thickness of 334 m, the aquifer has been affected by faulting and volcanic intrusions, that resulted in reduction of its porosity, transmisivity and consequently its potentiality for groundwater storage. Tawilah Sandstone may be considered as confined to semiconfined aquifer with transmisivity ranges between 4 m^2/d and 247m^2/d and the hydraulic conductivity varies between 0.015 m/d and 1.54 m/d. The wells yields range between 6.5 and 27 l/s, and the storage coefficient is ranging between 8 x10^{-4} and 0.052.

The water table below the contamination sources is shallow (< 6 m below ground surface), and fluctuates annually by about 0.5 m. The direction of groundwater flow is in a west direction towards the main stream of W.Rasyan. As Hawgala and Hidran areas receive significant quantity of water from floods, bonds and sewage effluents, th water tables stilled nearly at the same levels for about 30 years (1974 until 2003). It is noticed that the drastic decline in groundwater levels commensurate with abstraction development for urban areas such that in Hwban and Hayma areas.

3.3. Groundwater Contamination Sources:

Many different contamination sources have been observed within the study area, most are concentrated in Taiz plain (Urban and industrial sites). These are; a) underground septic tanks (Cesspoles) in the City of Taiz which receive about 3.7 Mm^3/yr of municipal waste water, b) municipal stabilization bonds (Burayhi sewage lagoons) receive about 0.72 Mm^3/yr, c) industrial waste water bonds (the bonds of factories), receive about 0.54 Mm^3/yr and cover about 4 hectare, and d) Ameria dam become also an environmental hazard, it is represented also one of the important surface water source, it covers about 7.38 ha and stores an average of 0.146 Mm^3 of flood water mixed with municipal refuses. e) The principal wet lands exist are Zeela and Hidran wet lands cover about 35 ha and have a deep, blackish soil layer, resembling peat and

apparently saline. Location of waste water disposal sites (contamination sources) were illustrated in Figure.2, examples of these sites are shown in Figure.6.

Figure.6. Photographs showing the various types of waste water effluents, a) cesspool of the houses, b) municipal effluents in the flow channels (W.Kalaba), c) wastewater disposal to Burayhi lagoons, d,e and f) industrial wastewater outlets to bonds and open stream at w.Al Hawban and W.Ad Dumyna.