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Integration of Remote Sensing (RS), and Geographical Information Systems (GIS) to evaluate the waste water quantity at downstream area of Al Roma Wadi

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Abstract

An evolution of demographic growth within the Al Quasseem region especially in the downstream area of Aroma Wadi have provoked environmental damage. Large quantities of wastewater are being thrown within the Wadi neighborhood without proper management. The main cities being affecrted are : Buraydah (the capital of Al Qasseem), Unayzah and Al Ras. Pollution resulted due to this wastewater has been investigated in this paper. Different digital methods (Remote Sensing, GIS and GPS) for collection and acquisition of geospatial data have been used. The satellite images for different dates have been taken and analyzed. The classification of these images have been made by Erdas Imagine software. The amount of wastewater has been estimated. The chemical composition of wastewater before and after processing has been determined. Death of some creatures has been identified. A true increasing of wild flora area has been observed. It is observed that after the last flood of Al Roma Wadi other areas have been indexed as damaged area within its downstream. The main results found in this paper are based on the data for the last ten years. It is suggested that this applied research may be continued in order to evaluate the impact of the wastewater on the groundwater in the Al Roma Wadi.

Keywords
Geomorphology, GPS, GIS, Geodatabase, Environmental Pollution.

1. Introduction

Water resources and waste water disposal are important issues worldwide. Sustainable water resources development and waste water management require advanced knowledge and technical skills. Al Roma valley is very important place in Al Qasseem and sustainable development its various areas have not been addressed properly in past. Ghazaw (2010) and Al-Salamah et all (2010) has done some work related to this in Al Qasseem Area. The government of Al Qassim Region is taking now

serious steps for sustainable development of Wadi Al Roma. The present paper has investigated some environmental issues of this Wadi using state of the art technologies.

The wastewater quantity which has been thrown in the Al Roma Wadi specially in the downstream area has been quantified first time. To estimate the quantity of wastewater in the Al Roma Wadi, the Remote Sensing and Geographical Information systems techniques have been used. Geospatial data has been collected and geodatabase has been built with high accuracy.

2. Methodology

The following steps have been followed in this research work:

• All the area affected by wastewater in the downstream of Al Roma Wadi has been identified by obtaining and analyzing the Satellite Image. Many visits have been made in the area to identify some important features related to the problem.

• Supplementary ground control points along the Al Roma Wadi were set using GPS tool (Static and RTK modes have been used) in order to finalize the Georeferencing operation at the time of making geometric correction of Image satellite by Geographical Information Systems software (ArcGIS9.0) and Remote Sensing (Erdas Imagine9.0) one.

• Data was transferred from GPS Tool to computer by using software (Leica Geo Office) to make all geoprocessing by static mode with high accuracy.

• Waste water was quantified by completing all geoprocessing steps of Image satellite such as mosaiking, Geometric correction and supervised classification.

• Geospatial data was exported from Remote Sensing software to Geographical Information Systems one for making all geoprocessing.

3. Description of Study Area (Dwonstrean Area of Wadi Al Roma)

Al Roma Wadi is considered as longest Wadi in Saudi Arabia because it starts from Al Madina Al Mounaoura Mountains known as its upstream in the West. It spreads up to frontier of Iraq in the North (see Fig. 1). A major part of the Wadi lies in Al Qassim which is termed as its downstream in present study. It has an important earth dam which was flooded in the past storm (see Fig. 2).

The downstream area of the Al Roma Wadi starts from Al Rass city passing by Unayzah city until North East of Braydah (Village of Al Rabiyia). In this area we observed a many kind of human activities such as :

• The activity to build building within the town. During the last flood, many private proprieties damaged because of high rains.

• The activity related to agriculture. It has depleted the groundwater at a very high rate.

• The industrial activity due to which the network of roads has been expanded.

• The environmental activity such as solid and liquid waste storage specially wastewater storage for each city of Al Quasseem region (Al Rass, Unayzah and Buraydah). It is worth mentioning that a large number of villages near the main cities are also the source of wastewater and environmental pollution.

Fig. 1 : The history route of Al Roma Wadi.

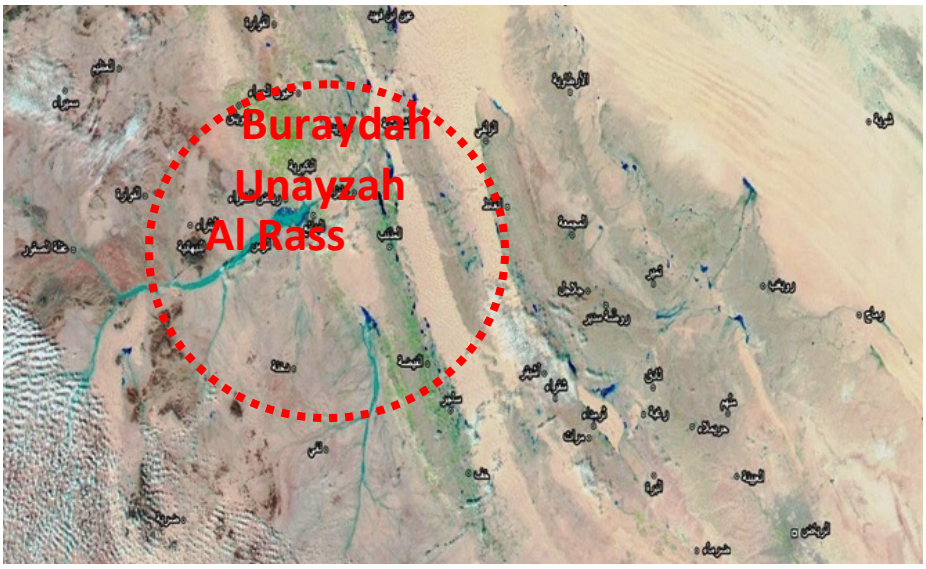

Fig. 2 : The Present route of Al Roma Wadi.

3.1 Main processing stations of wastewater

In Al Quasseem region specially in the big cities such as Braydah, Unayzah and Al Rass, the wastewater coming from the underground network of each city to the processing station in order to treat it and return it to desert with a minimum polluting impact. Each processing station has been selected near the Wadi. The following are the main stations :

• Al Rass processing station located in Northern – Weastern area close to the road linking Al Rass and Riadh Al Khabra.

• Unayzah processing station located in North of Unayzah close to the electrical factory near the highway linking Al Madina Ryadh.

• Braydah processing station located in East of Braydah city closed the Eastern ring road.

3.1.1 Processing methods used

Taking into account the observations during the field visits to these stations we found that two methods of processing have been used : the first is the secondary processing which is being used until now in Al Rass station, the second one is the tertiary processing being used in Unayzah and Braydah stations. Concerning the first method wastewater is pumped to aeration basins after passing it from sedimentation basins and finely processed water chloral solution is added to it in order to neutralize. Then it is pumped it to the Al Roma Wadi. The second method is the modern one used in Saudi Arabia. The processing system is composed of :

• Separation unit at the entrance of the station which separates the macro solids related matter.

• Aeration basins unit by oxygen to activate bacteria in order to speed up the biologic processing.

• Sedimentation basins unit to separate processed water from the mud.

• Sand filter unit to purify the processed water.

• Chloral solution unit to pump chloral to processed water.

• Separation mud unit which composed by spiral transporters and basins to neutralize mud.

Table 1 indicates different wastewater stations and their recent capacity. Some quantity of this water has been used to irrigate municipality trees in Braydah city.

Table 1: Waste water stations in Al Quasseem region.

City	Station name	Processing system	Powerful Capacity (m^3/day)	Quantity of water processed (m^3/day)	Quantity of water used (m^3/day)
Al Rass	STO405	Secondary	20800	14000	**0**
Unayzah	STO305	Tertiary	56800	18000	**0**
Buraydah	STP205	Tertiary	110400	80000	**35000**

3.1.2 The chemical composition of wastewater before and after processing

The chemical analyze on wastewater shows that the chemical composition of this water is almost the same for three processing stations (see table 2). This chemical composition shows that pollution level is less than that found in processed water in industrial countries.

Referring to the documentation obtained from the local administration of water for each city it was observed that:

• The T. ALK. increases when wastewater is in or comes out of station.

• The SS, TCF, COD and BOD5 increase when wastewater comes out of station.

Table 2 : The chemical composition of wastewater before and after processing.

Out	In	Chemical test
341.667	384.333	**T. ALK. (mg/L)**
7.34	7.35	**PH**
9.375	17.875	**PO_4 (mg/L)**
1133.333	1233.333	**T. S. (mg/L)**
205.500	180.333	**S. S. (mg/L)**
0.173	---	**Free. CL_2 (mg/L**
53.817	218	**BOD_5 (mg/L)**
250.667	370.500	**COD (mg/L)**
$23.750x10^2$	$38.073x10^5$	**TCF – (MPN/100 ml)**
$3.433x10^2$	$6.397x10^5$	**FCF – (MPN/100 ml)**

4. Quality of wastewater along the Al Roma Wadi

Referring to the field visits prepared for each site it was observed that the processed water thrown in the Al Roma Wadi does not qualify to the international specification. Many pollutant elements were found in water coming from stations (see Photo 1).

Photo 1 : The quality of wastewater after processing.

5. Methodology to estimate the quantity of wastewater in the downstream area

In order to estimate the quantity of wastewater along the downstream of Al Roma Wadi, a methodology integrating the Remote Sensing and geographical Information Systems was used. Different Image satellite for different periods to compare the quantity after geoprocessing by software (Erdas Imagine9.0) was used. To take into account the actual period of wastewater sites we have used also the GPS tool to calculate the actual area for each site. To elaborate this surveying work, many ground control points have been set in the field along the Wadi. After geoprocessing all the geospatial

data, was exported to Geodatabase in Geographical Information Systems software (ArcGIS9.0). In this way the wastewater quantity of each site was found.

6. Steps to calculate the quantity of wastewater along the wadi

6.1 Image Satellite Geoprocessing

We have used image satellite delivered from Space Research Institute at King Adbulaziz City for Science and Technology for two periods (2003 and 2008) taken by SPOT5 satellite. The geoprocessing has been done by Remote Sensing software (Erdas Imagine9.0). First mosaiking process was made in order to gather the area of study. After that the subset process was made to simplify the supervised classification process. One of The result of this last process have been shown in following figure (see Fig. 3).

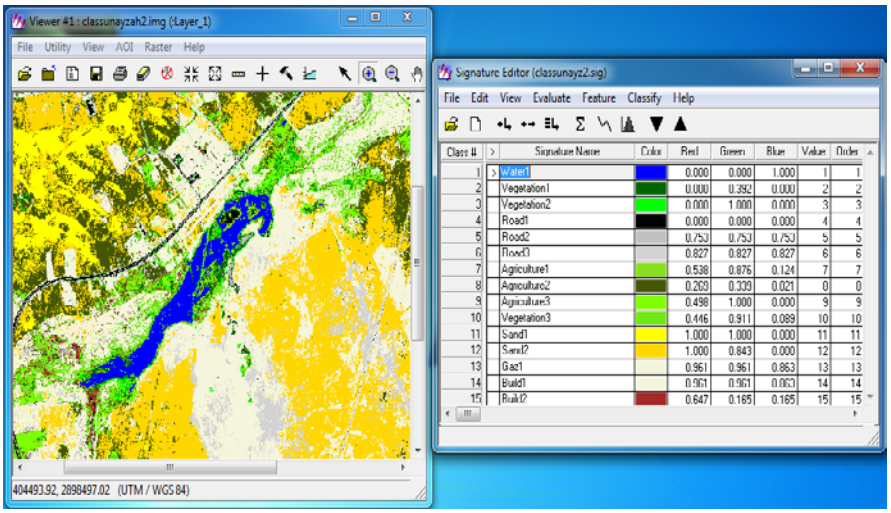

Fig. 3 : Supervised classification using SPOT5 satellite image (Unayzah station).

Referring to the preceding figure of supervised classification we can conclude the following points :

• Concerning Al Rass area the impermeable soil allows to stop the filling of water in the underground. The length of this area during this period is 1200 m because earth dam has been made at downstream of this water.

• Concerning Unayzah area a concrete dam located near electrical factory of Al Quasseem allows to stop the stream water. In this area we found a complex soil and fractured rock which allows the possibility of recharge of water in the underground.

• Concerning Buraydah area a recharge of water to the underground is greater than that of two preceding sites because a great mass of sand has been found in this area. Also, the substratum rock is characterized by a lot of tectonic joints and fractures. During this period the length of wastewater spread is less than 2500 m and the width of site is less than 20 m on the average.

6.2 Surveying using GPS Tool

GPS was used to evaluate the area under wastewater during 2010 period for the three sites. . Some ground control points have been proposed near the geodetic points given from each municipality of three cities. The table 5 illustrates the geodetic points and a ground control points proposed for this research.

Table 5 : Geodetic and ground control points proposed along the Downstream of Al Roma Wadi.

Z (m)	Y (m)	X (m)	N° GCP
642.683	2891398.045	397652.482	**Univ1**
678.579	2889707.206	402174.101	**1000**
679.639	2889828.936	402116.067	**7024**
642.683	2891398.045	397652.482	**U3**
642.683	2891646.326	398112.812	**5422**

6.3 Calculate the area of wastewater by ArcGIS9.0

In order to calculate the area of wastewater for each site it must be necessary to export geospatial data from Remote sensing software after supervised classification to ArcGIS9.0 and after that we can calculate each area as following :

• Export geospatial data from Remote Sensing software to ArcGIS9.0.

• Visualization of geospatial data as layers in ArcMap to indicate the area of each one.

• Codification of each area using the geocode in the geodatabase by using ArcCatolog and visualize it as attribute data with possibility to calculate the sum and statistic parameters which precise the kind of classification of these geospatial data in ArcMap.

7. Results of wastewater area for three sites

7.1 Actual wastewater area in downstream Wadi

By using Remote Sensing, Geographical Information Systems and GPS Tool we have found the exact area on which wastewater is pumped downstream of Al Roma Wadi. The figures below (see Fig. 4, 5 and 6) show the results concerning the area of each site. In Al Rass site we observe a great quantity from 1500000 m2 (2008) until 4000000 m2 (2010). There are two possible reasons for this, first Al Roma wadi at Al Rass region contains a thick soil clay layer and second the local water administration has build a dam at the downstream of site to stop water.

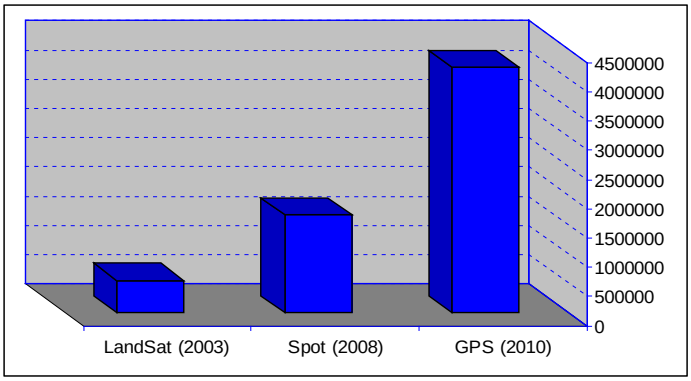

Fig. 4 : Calculate the wastewater area with ArcMap, Al Rass site

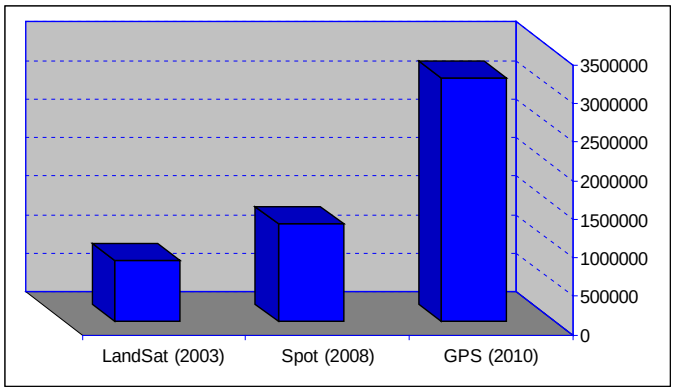

Fig. 5 : Calculate the wastewater area with ArcMap, Unayzah site.

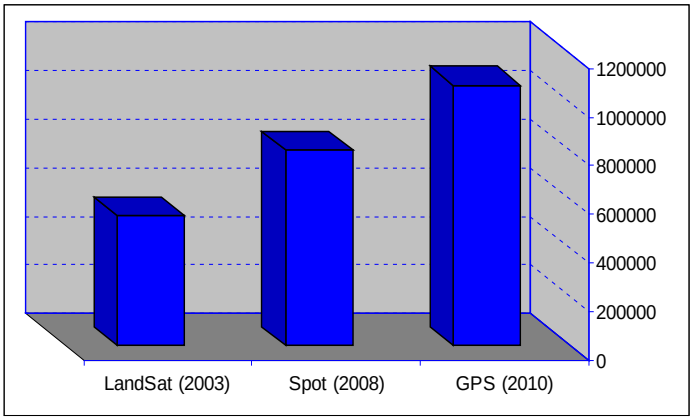

Fig. 6 : Calculate the wastewater area with ArcMap, Buraydah site.

In Unayzah site we observe too a great quantity from 1200000 m2 in (2008) to 3000000 m2 in (2010). To explain this increasing of quantity two reasons are possible, first at the left side of Al Roma Wadi Al Roma at the North of Unayzah there is a big sand dune very permeable and second at the right side a fractured substratum rocks has been indexed which allow to recharge water underground.

In Buryadah site we observe a small difference from 2008 to 2010 (750000 m2 to 1100000 m2). To explain this phenomena of almost same quantity of water from 2008 to 2010 we found a big sand dune in this region in which the great part of water is recharged into underground

7.2 Vegetation area around wastewater along Al Roma Wadi

The wastewater allows growth of a very large quantity of vegetation around the area of its accumulation. This vegetation represents a natural dam which stops the stream water during the period of flood. It is interesting to find a solution to exploit benefits of this vegetation.

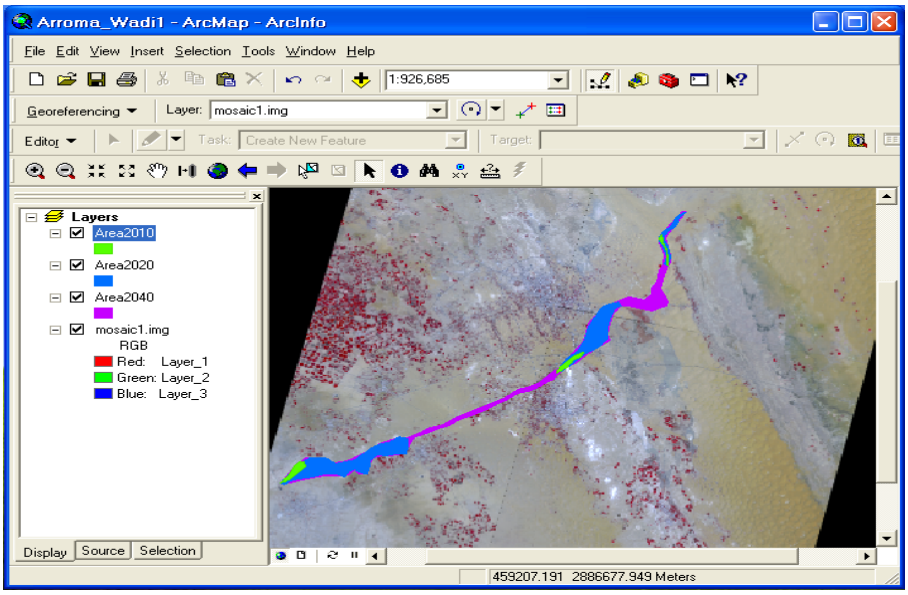

Fig. 7 : Area evolution of wastewater during the future long term by ArcMap.

7.3 Wastewater area and vegetation in future 10 years

By the reason of urban growth during the future 10 years specially the villages and cities close to the Al Roma Wadi in the downstream area we will observe a increasing of quantity of wastewater thrown in the Al Roma Wadi (see Fig. 7, area2020).

7.4 Wastewater area and vegetation in future 40 years

In long term (up to 2040) the urban growth is becoming very important resulting to a very large quantity of wastewater associated with a great mass of vegetation., A river improvement work in downstream area may be unavoidable (see Fig. 7, area2040). It may help in recharging of properly treated wastewater into the underground fresh water.

8. Conclusions and recommendations

8.1 Conclusions

This applied research an initial step for a future research project to investigate and evaluate the influence of disposal of wastewater on Al Roma Wadi using a new technology such as Geographical Information Systems, Remote Sensing and GPS.

To carry out this applied research a plausible methodology has been followed taking into account the field investigation along the Al Roma Wadi in which the quantity of wastewater has been quantified and its environmental impact has been evaluated. State of the art equipment, software and technology has been used in order to collect geospatial data and making geoprocessing to build available geodatabase with high accuracy.

The main conclusions are summarized as follows :

• The quality of wastewater depends on the huge quantity of wastewater coming from the network of each city. In reality, we observe not conformity of quality with international specifications, so this situation allows to pollute the underground fresh water table up to 100 m of depth.

• Referring to supervised classification it is concluded that the quantity of wastewater increases from period to another. However vegetation around the wastewater increases.

• After export geospatial data, building geodatabase and calculating the area using Geographical Information Systems software (ArcGIS9.0), it is found that there is recharge of wastewater into

underground hence polluting the subsurface strata. Only Al Rass region has a good quality of clay soil which minimizes recharge.. Concerning Unayzah and Buraydah the there is sufficient amount of recharge of wastewater into the subsurface strata.

8.2 Recommendations

A large scale research project is recommended to investigate the sustainable development of Al Roma Wadi. All aspects of hydrology, water resources, geology, groundwater exploration/modeling and environmental pollution may be included.

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