STRATEGIC PLANNING THROUGH MAPPING OF WATER POLLUTION IN LACK OF INFORMATION SYSTEM UTILIZING GEOGRAPHIC INFORMATION SYSTEM (GIS)

Lake Maryout, Alexandria, Egypt

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Abstract. Strategic planning always requests supporting tools to defeat lack of data problems, which is a common drawback in our planning system as a result of several reasons. This paper is an extensive overview of the recent application of Geographic Information Systems (GIS) in the domain of water contamination in lakes. The authors try to establish a GIS mapping technique, which is customized for Lake of Maryout in Alexandria city, Egypt demonstrating various GIS analysis techniques/approaches applied to a diversity of real-life engineering endeavors in the water contamination control management sector in a lack of data system. First, the reader is concisely acquainted with the major steps of utilized mapping technique and how they are conducted. Second, the technique would be applied to define degree of water pollution distribution in Lake of Maryout. Finally, the output maps would be analyzed to delineate a quick and long term strategy of solution.

1. Introduction

Many of the environmental impacts of human activities, the current impacts and the future impacts, are and will be unknown to us. But still the currently available scientific knowledge about the impacts of societies on ecosystems is the basis of decision-making in environmental policy and management, i.e., usually we must first know with certainty what the impacts are before taking action (Korhonen, 2007).

Korhonen (2007) extends his considerations that during the last 10 or 15 years, several studies have been published, which show that environmental policy, planning and management, practiced either by government or by industry, can result in ‘problem displacement’ or problem shifting instead the intended problem solving. Problem shifting has occurred due to fragmented approaches in policy and management such as a focus on a single environmental medium, e.g., air, while neglecting the shifting of the wastes and emissions to landfills or to water, or a focus on production while consumption emissions and wastes increase as a result.

In the Third World, existing paradigms inhibit the collection and synthesis of useful data to such an extent that not only is the ability to assess water quality seriously compromised in many countries, but more importantly, they erode the capability of national governments to make cost-effective judgments about water quality management, water resource policy development, and investment options (Ongley, 1993).

In many countries, data collection is largely disconnected from the users of data. Data programs are, therefore, inefficient, have poorly defined or unrealistic objectives, and are not broadly useful to environmental management agencies or for water resource policy development. At the political level, data programs are considered expendable and are being reduced or eliminated in many countries. Many governments are neither convinced that data programs can be effective, nor that water quality data are essential for water resource management. Consequently, national capacity to generate essential data is diminished (Ongley, 1993).

In the meanwhile, an increasingly important task of scientists working on assessment panels is to have sufficient data to be capable to give the right advice for decision makers and urban planners.

The extent to which they can provide a complete description of the situation is very limits as they always suffer from lack of information and data.

The Hyderabad Water Management Information System (HiWaMIS) would be a good example to this research. The HiWaMIS was implemented as a prototype in support of sustainable water and pollution management in urban industrial areas in India. Water quality was sampled in ground and surface water bodies and managed in the HyWaMis Database together with information about industries and their effluent discharge. The collected data were analyzed in GIS and presented to the stakeholders in the form of thematic maps integrated in the system with a freely available GIS viewer (Klingseisen et al., 2005; Schönerklee et al., 2007)

This paper is a trial to establish a GIS mapping technique, as an available technology, to support planners, and decision makers in their work. This mapping technique is presented in the form of tailored case study for Lake of Maryout in Alexandria city, Egypt demonstrating various GIS analysis techniques/approaches applied to a diversity of real-life engineering endeavors in the water contamination control management sector in a lack of data system.

It is an important issue for two reasons. First, the ways that the GIS currently provide the issue reveal a reliance on this technical tool as a decision-making tool. Second, data collection is an expensive process and takes a long time, which assists in the delay of decision and in turn in strategic plans.

The paper proceeds as follows. In section 2, details concerning the physical aspects and deteriorating water quality of the Maryout Lake are described. In section 3, an introduction to the capabilities of GIS in the field of lack of information is spelled out. In section4, the mapping technique is described to examine contamination of water in the lake in the lack of information which the main problem is facing us.

2. Geographical setting:

Lake Maryout is one of the northern Egyptian lakes, located in the north western coast of Egypt. The lake extends for 80 km along the North West coast of Alexandria and 30 km south and is divided into a number of basins by highways and railroads. In contrast to other northern lakes in Egypt, Lake Maryout is a closed lake, not connected with the sea. The average depth of the lake ranges between 0.55 and 1.2 meter. The level of water surface is -3 meter compared to Average Sea Level. The area of the lake extends for about 20 km between 31° 01´ 48″ and 31° 10´ 30″ North and 29° 49´ 48″ and 29° 57´ 00″ East.(Achthoven et al., 2004).

2.1 DETERIORATING WATER QUALITY:

Due to the discharging of industrial, agricultural wastewater and some municipal wastewater into the lake, the water quality of the lake has declined considerably. This decline in water quality is continuing despite partial treatment of some discharged industrial and municipal wastewater (CEDARL, 2006).

Where the physical characteristics of Lake Maryout concerning physical characteristics of water, the following are the main parameters of water according to researches conducted in the lake: 1) Salinity : 42.2 (0/000) and POD : 0.56 mg/L, 2) Heavy Metals (Fe : 8.1 (µg/L), Ni : 0.09 (µg/L), Zn : 0.225 (µg/L), CU : 0.450 (µg/L), Pb : 0.379 (µg/L), and Hg : 0.0125 (Nano gram/L))

Concerning pollution problems we have past massive discharge, which affect water and sediments. Also, we have current discharges into the lake represented in: 1) El Qalaa drain: domestic sewage, industrial and agricultural wastewater, 2) Al Omum drain: agricultural wastewater, 3) Domestic Sewage (treated or not), and 4) Numerous illegal discharges.

Decision makers would take their decision to stop these charges by indicating the factors that affect the lake seriously which will be detected through GIS application, so that urban planners and decision makers can take actions to control pollution.

Figure 1. Arial photo illustrates four basins of Maryout Lake.

Lake Maryout is one of the important resources in Egypt but it is facing various pollution problems, as lake is divided into four Sub-basins, they are as shown in figure 1:1) Main basin: 25 km^2 (6,000 acres), 2) Fisheries basin: 4.2 km^2 (1,000 acres), 3) North West basin: 12.5 km^2 (3,000 acres), and 4) South West basin: 31.5 km^2 (7,000 acres) as shown in figure 1.

TABLE 1. The main characteristics of Lake Maryout basins

	Basin name	Depth	Vegetation Cover
1	Main basin: 25 km2 (6,000 acres)	0.5 _ 3 m	60 %
2	Southwestbasin:31.5 km2 (7,000 acres)	0.7 _ 2 m	70 %
3	Northwest basin: 12.5 km2 (3,000 acres).	0.4 _ 0,6 m	20 %
4	Fisheries basin: 4.2 km2 (1,000 acres).	0.4 _ 3 m	15%

The most polluted basin is the main basin specially the eastern part of it. We are concerned in our research in water pollution as nearby the lake there is a wide area of newly-reclaimed land which includes a number of human settlements, mainly rural. Most of these settlements discharge their domestic wastewater (sewage) into irrigation and drainage canals, which discharge their water ultimately into the lake through El Qalaa drain. (Barnard and EL-Din, 1997)

Also there is an industrial complex nearby the lake (mainly petrochemical industries); which discharges industrial wastewater into the lake after some sort of treatment.

Daily, a very high percentage of fluxes are poured into the lake from El Qalaa Drain, and El Omum Drain. Theses fluxes of pollutants as shown in figure 2 are follows: 1) Sanitary Drainage 122.6 tons/day, 2) Industrial Pollutants 180 tons/day, 3) Agricultural drainage up to 6 million cc/day, and 4) Biological pollutant.

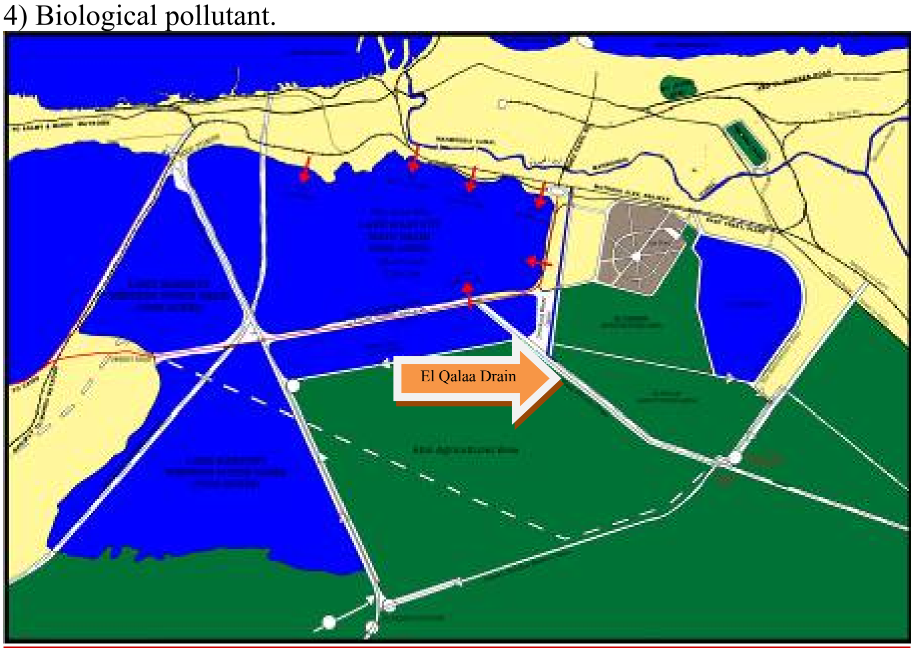


Figure 2. Map illustrates sources of pollutants in red arrows

3. Capabilities of GIS in Mapping of Water Pollution

A GIS can provide a spatial database of information to support modeling of phenomena. The GIS supplies the spatial data in a form that can be input to deterministic or statistical models. The spatial power of the GIS database is used in full by the model, and more detailed and spatially averaged results are produced. This represents a high level of integration and achievement to help decision makers. In general, the strength of GIS is that it is possible to process the data sets using any type of numerical analysis procedure. In particular, certain procedures are valuable for data visualization and analysis, including image processing techniques, virtual reality, and simulation modeling. The digital approach to storing and processing spatial or image data is a fantastic boon to these analyses of data, and the capabilities have yet to be fully realized (Naamani et al., 2001).

GIS can help in urban planning as it estimates future demands and planning the timed expansion of the water system. These estimates specify the required system improvements, and structure a long term capital investment program (Psdcolo and Brebbia, 1998).

3.1 MAPPING TECHNIQUE

To start the application here is the following procedures done, first stage data collection and preparation stage, including Map Projections and Coordinate Systems and Sources of Spatial Data, second stage designing and implementation of system, third stage the analysis technique, finally the results of the application.

3.2 DATA COLLECTION AND PREPARATION

The project deals with a dynamic system involving surface water and groundwater. It is therefore essential to have an idea about the temporal changes (time related variations) of various parameters like surface water quality, groundwater levels.

Unfortunately, no consistent data are available for the whole study area.

Including satellite images for the case study and photos illustrating the place of the drain and samples of pollution in the lake, by combining different datasets in a map identified locations of industries and other sources of pollution. Maps are also an efficient way to raise public awareness by pointing out problem areas.

This stage includes also map projection for the images to start working on them using figure 2 to illustrate places of drain (shape file drain) and figure 3 indicate sources of pollution (shape file sample of pollution).

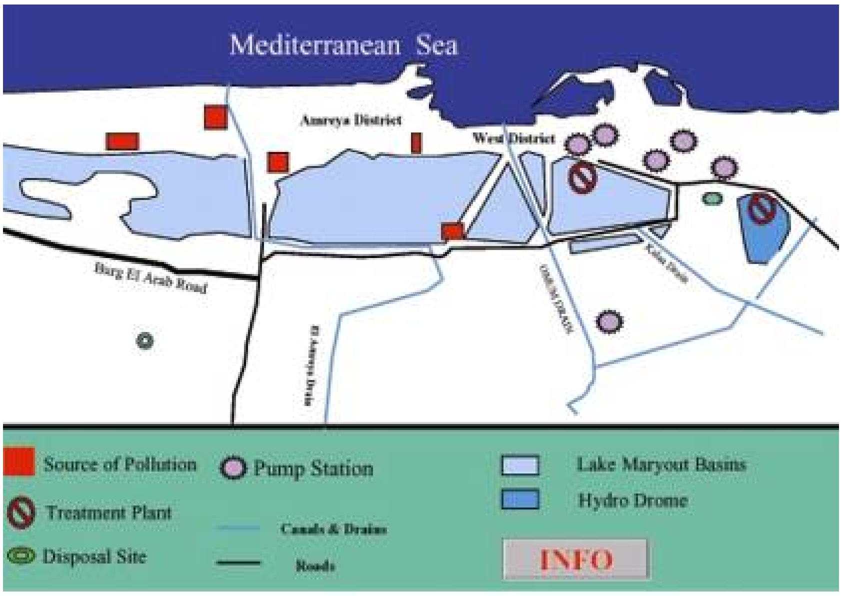


Figure 3. Map illustrates Drain and Samples of pollutant. Source: (CEDARL, 2006)

3.3 DESIGNING AND IMPLEMENTATION OF SYSTEM.

This stage is to design the Geo data base so that case study can be build, so for these georeferenced objects the branch and partially the effluent discharge could be extracted from the database to be used for thematic maps.

Topographic data defining the spatial context were provided in the form of shape files and a topographic map of the region. Data layers include several layers like lake, sample of pollution, drain, point away from drain, these layers differs from being point layer, line layer, polygons layer.

3.4 ANALYSIS TECHNIQUE

We'll introduce our own query and the flow chart that the work was based on it, illustrating way of thinking in solving the problem in order to help decision makers.

It is needed to design three maps: 1) Drain Map, 2) Samples of pollution, and, 3) Depth Map.

3.5 GIS METHODOLOGY

In the flow chart shown in figure 4 the mapping procedure is summarized in three parallel steps:

Step 1: Samples of pollutants are indicated by point shape file (vector), so we convert it to raster through interpolation using Inverse Distance Weighted (IDW) method. IDW is the most appropriate method comparing to SPLine and Kriging methods. SPLine needs direction, while Kriging needs extreme data (too small or too large data). The output of IDW is POL DIST.

Step 2: Establishing polyline shape file presenting drain and going through spatial analysis (straight line) providing an output Distance Map, then re-classifying output to be able to analyze it into an output Re-classified Drain Map.

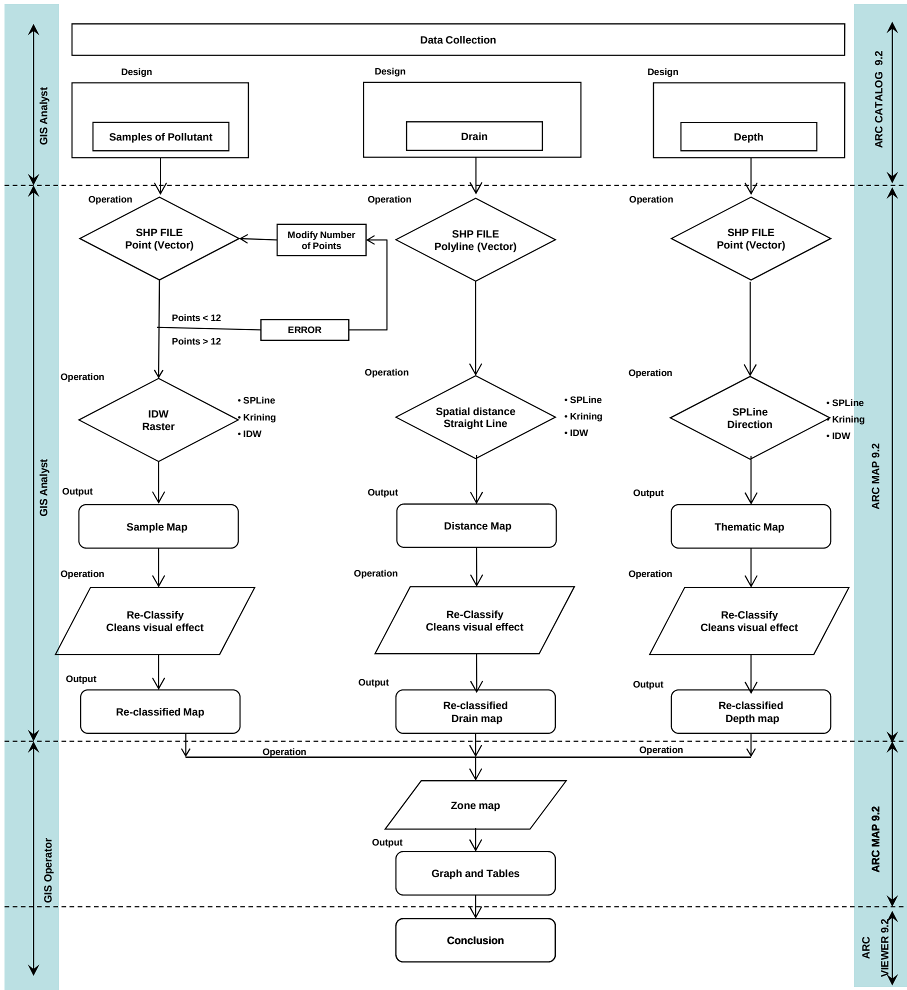


Figure 4. Flow chart shows the three steps mapping technique employing GIS technology

Step 3: Establishing point shape file representing Depth (vector), so we convert it to raster through interpolation using SPLine way, output Thematic Map, which is re-classified into output Re-classified Depth Map.

4. Results

From the analysis technique it shows that black refers to high pollution and whiter to low pollution. As shown in figure 5 as we go further from the drain the pollution decreases. In graph 1 a relation between distance from drain and percentage of pollution is depicted, hence, as we go further the pollution decreases. It is a significant point for the decision makers and urban planners to take action to solve pollution problem of the lake. Figure 5 (colored map) and figure 6 (gray scale map) show that as we go far from drain points pollution decreases, while figure 7 (colored map) and figure 8 (gray scale map) show that depth effects pollution. As we go deeper the pollution increases.

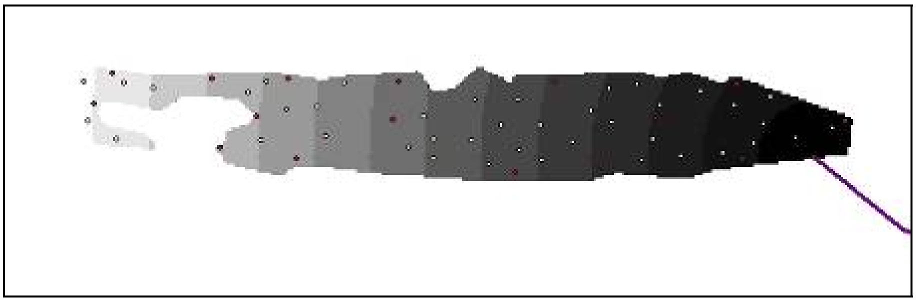


Figure 5. Distance Map (gray scale map) shows as we go further from drain point pollution decrease. High polluted points are black and low polluted points are white

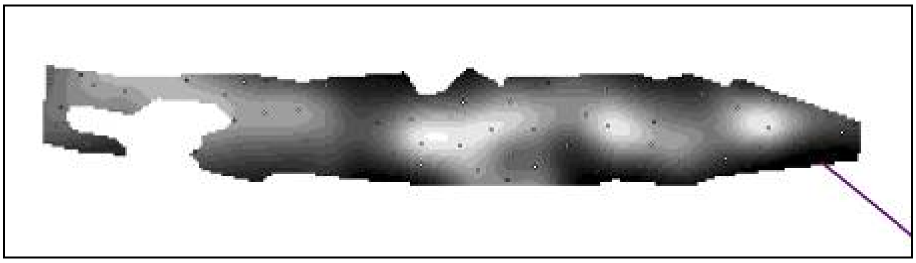
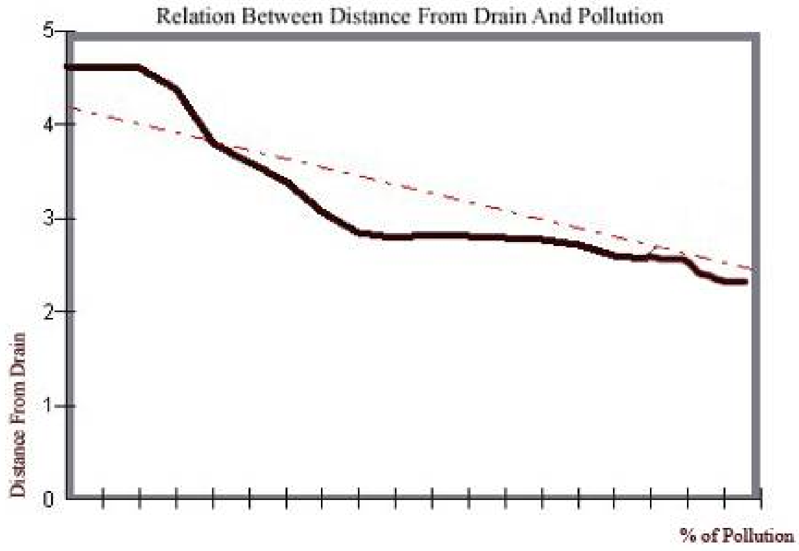
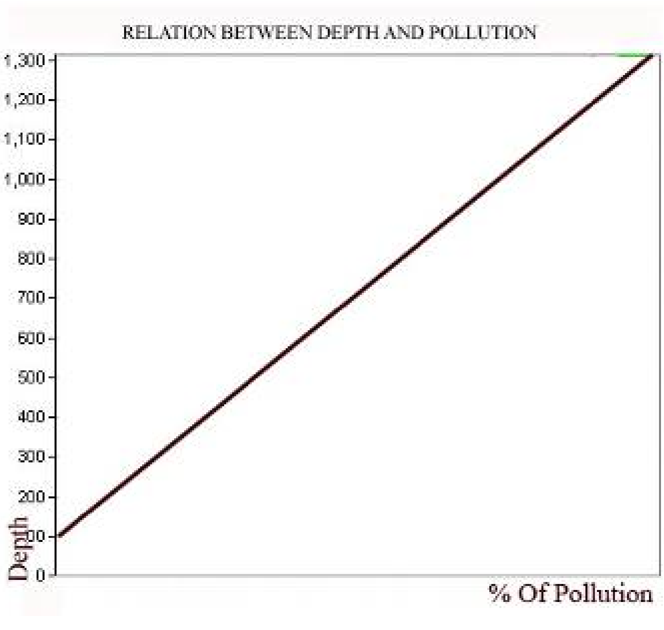


Figure 6. Bathymetric Map (gray scale map) using splin shows as depth increases pollution increases as well. High polluted points are white and low polluted points are black

Figure 6 shows how depth effects pollution as we go deeper the pollution increases. Graph 2 illustrates relation between depth and percentage of pollution, as we go deeper the pollution increases.



Graph 1. Indicates that as we go further from drain pollution decreases



Graph 2. Indicates that as depth increases pollution increases

5. Conclusion

GIS is a capable decision support system tools in a lack of data environment. The mapping technique, which is provided by GIS technology assists in offering planners when preparing strategic plans clear and correct information. It posses easiness in use through visualizing outputs in thematic maps.

The research also recognizes that Lake of Maryout has a crucial contamination problem. The water waste policy that adopted by the Alexandrian Governorate highly polluted the Maryout Lake.

The mapping technique adopted by the authors concludes that pollution in the lake increases in deeper places and near the waste water outlets as well.

There is a great demand to stop that spilling of waste water in the Lake and starting cleaning the contaminated soil in the lake.

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