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A MODIFIED METHOD FOR SITE SELECTION OF NUCLEAR INSTALLATION USING GIS CASE HISTORY: RADIOACTIVE WASTE DISPOSAL SITES

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ABSTRACT
One important scope of the Siting and Environmental Department that belongs to Egyptian Regulatory Body (ENRRA) is conducting search in the area of site selection and evaluation of nuclear installations. International Atomic Energy Agency developed an Approach for its member's states 1994 using in site selection and evaluation of radioactive waste disposal repositories. This approach consists of planning, survey, and characterization and confirmation stages. But, the implementation of such an approach is associated with difficulties when it is applied manually. In the last decades, Geographic Information System (GIS) is commonly used in most fields of sciences. In this work, a Modified Method (MM) and GIS system have been used to locate the most suitable sites, for radioactive wastes borehole disposal facility. To facilitate the implementation of IAEA' approach some modifications have been introduced. Here, in this MM the site survey stage is divided into three phases, each of them has its own criteria and GIS multi-criteria feature has been applied. This MM has been tested in locating optimum sites for borehole disposal facilities with certain criteria The MM is characterized by its easy use and save time.

INTRODUCTION
A Geographic Information System is designed to store, retrieve, manage, display, and analyze all types of geographic and spatial datasets it produces maps and other graphic displays of geographic information for analysis and presentation. In addition to, Map attributes implements a professional-strength relational database. Attribute data may be freely joined to and detached from geographic layers and tables. Relational data manipulation is integrated with robust and powerful geo processing for spatial queries, and other location-based analyzes.

International Atomic Energy Agency has mentioned and indicated the importance of the application geographic information systems in decision support. The use of (GIS) is useful for dealing with this issue from another angle. From the point of view of supporting decision making, GIS can be considered as a system to support decision making involving the integration of spatially referenced data in an environment of problem solving. The GIS can be considered as a digital database, with specific purposes, in which a common spatial coordinate system is the primary means of storing and accessing data and information. This system allows the integration of a wide range of geographic technologies. Such global positioning system (GPS) and computer-aided design (CAD), have the ability to perform many tasks using the data stored and can be integrated with techniques and analytical support for decision making. Another important point to note is that this type of selection problem has a strong spatial component, since it involves a set of alternatives (sites), geographically defined, from which the choice is made of one or more alternatives in terms respect to a given set of evaluation criteria. The alternatives are defined geographically in the sense that the analysis results (decisions) depend on their spatial arrangement. In this case, the evaluation criteria are associated with geographic entities and relations between them and therefore can be represented in the form of maps, from which the choice is made of one or more alternatives according to the evaluation criteria.

MODIFIED METHOD
IAEA developed an approach for near surface and deep disposal of radioactive wastes (IAEA, 1994). In this approach, it could be recognized four stages; (A) conceptual and planning stage; (B) area survey stage (C) site characterization stage (D) site confirmation stage (Fig.1).

Fig. 1 Flowchart of a Systematic approach for site selection of NPPs.(After IAEA,1994)

The main purpose of site survey stage is to identify one or more candidate sites after considering both safety and non-safety criteria. This involves the study and investigations of a large region that may be extended to cover the whole country. For that, IAEA approach is associated with many difficulties due to large area in which searching for and multi-criteria we use. In the present study, the area survey stage was developed by dividing it into three phases, the excluded site phase, the potential site phase and the candidate site phase (Fig.2).

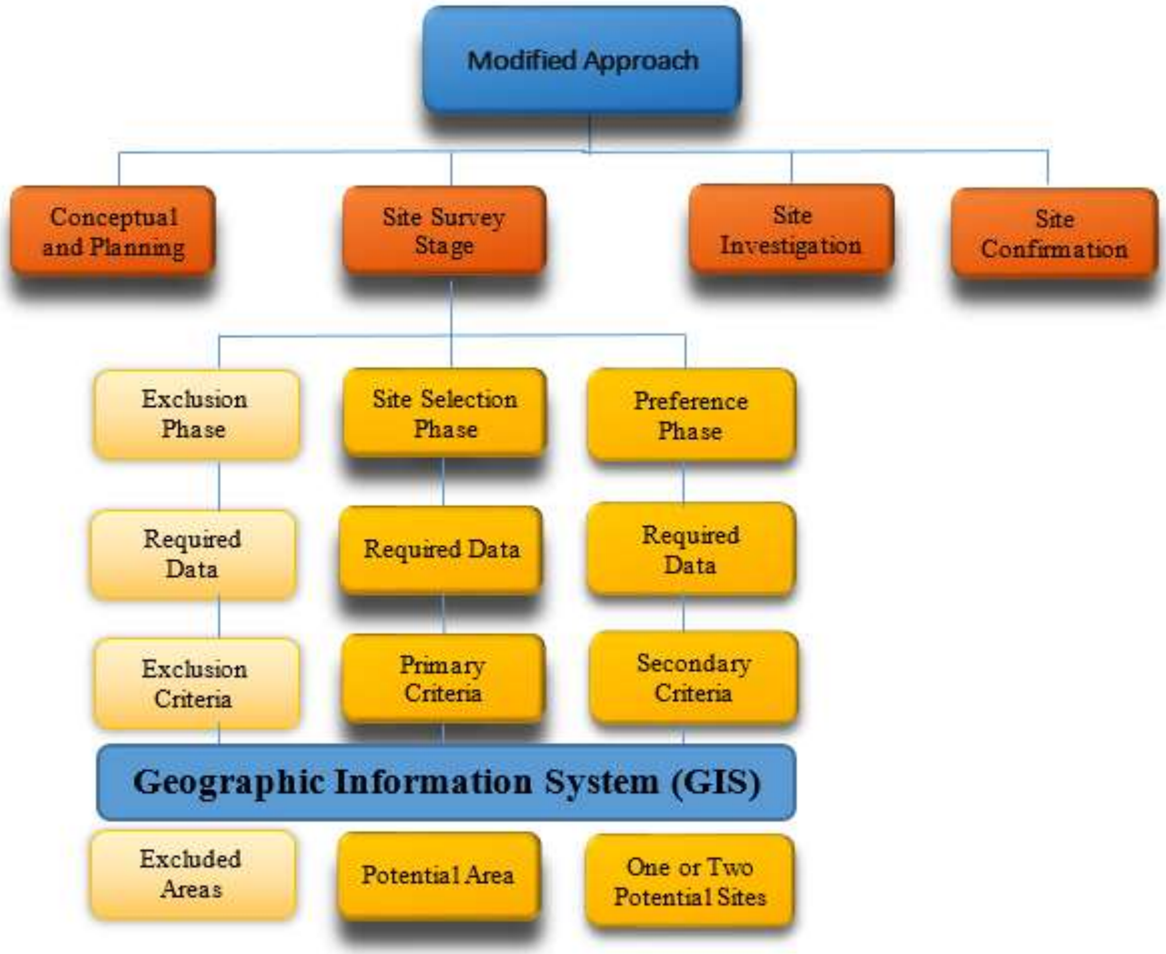

Fig.2 Development of MM for site selection of radionuclide waste disposal repository

The first phase represents the exclusion of areas that meet the exclusion criteria and have negative impacts on the safety of the disposal facility. The second phase represents the potential areas or sites that meet the primary criteria and the third phase represents the preference between the potential sites to select one or two candidate sites based on the secondary criteria.

The Geographic Information System is generally applied in the second and third phases to choose candidate potential sites that meet primary and secondary criteria from large studied area. It is worth-mentioning that the first exclusion phase is of great importance in facilitating the practical use of GIS by reducing the GIS-layers as seen in (Fig.3).

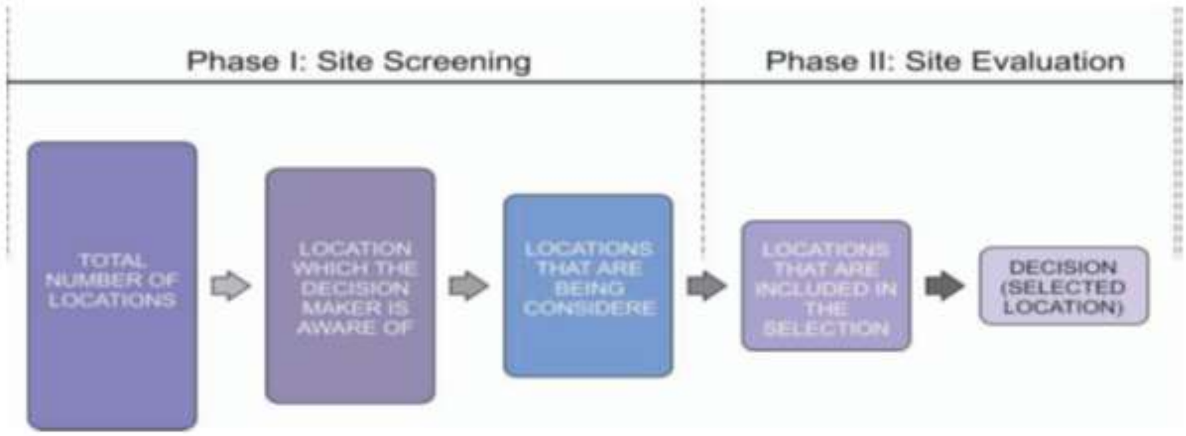

Fig.3 Site-Base Multi-Criteria

The selection of a site proposed for radioactive waste repositories shall be characterized by certain criteria. The criteria can be classified into safety or non-safety, environmental and economic related criteria. Borehole disposal type is fitting the disused sealed radioactive wastes. The site proposed for such a type of disposal shall be characterized by the following criteria.

1) Exclusion criteria: this criteria can be summarized as follows;
- Areas of critical political situation.
- Areas of high tectonic and high seismicity.
- Areas of future agricultural land.
- Areas of archaeological and natural parks.
2) Primary criteria; there criteria are usually used to allocate more than one potential sites within the survey area. The criteria can be summarized as follows:
- Arid climate < 130 mm/yr precipitation.
- Thick deposits of sand and gravel (alluvium) > 100 m thick.
- Deep water table, > 150 m below land surface.
- No potential for flooding.
3) Secondary criteria: these criteria are normally used to reduce the selected potential sites to only one or two sites. The criteria can be summarized as follows:
- Land owned by the government.
- No volcanic activity in the geologically recent past.
- No valuable subsurface resources such as oil, gas and gold.

BUILDING UP GIS DATA-BASE

The siting of a repository for radioactive waste disposal is a long process and needs a lot of data to govern the suitability of such an area to receive this kind of critical facilities. As seen in (Fig.1) site survey stage comprises three main phases, each phase requires some types of data. These data are represented by physical, geological, geophysical, hydrogeological and environmental data. Seismological data in the form historical and instrumental earthquakes that affected Egypt along its recent geological history has been acquired (Fig.4).

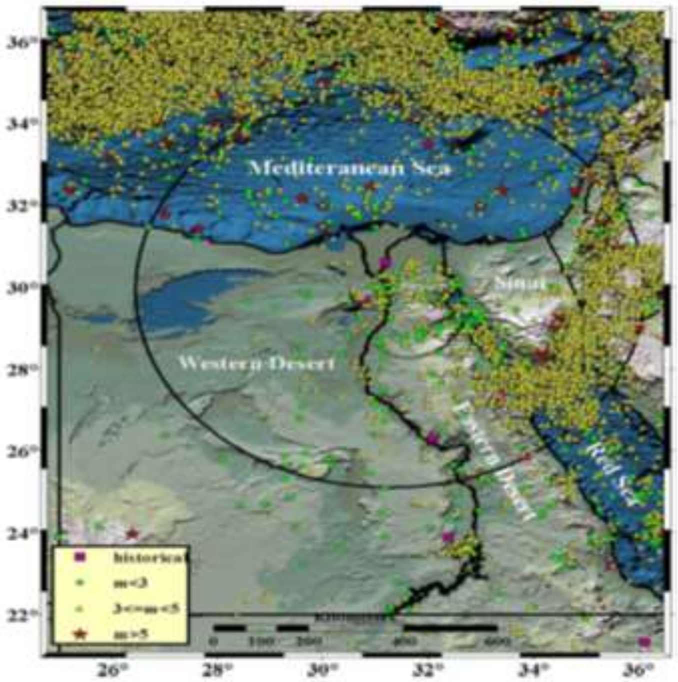

Fig.4 Seismicity map of Egypt and its Surrounding from 2200 BC to 2014 (Badawy et al. 2016)

This data will help in defining the major seism-tectonic trends that affect Egypt and the dislocation areas. Accordingly, the high tectonic and high seismicity regions can easily be classified and discarded as potential sites for radioactive waste disposal. Information about the mean annual precipitation rate should be obtained to define the areas where the potential for flooding may occur. The acquired data is in the form of a map showing the distribution of the mean annual rainfall on the whole country as seen in (Fig. 5) (EMA, 1997).

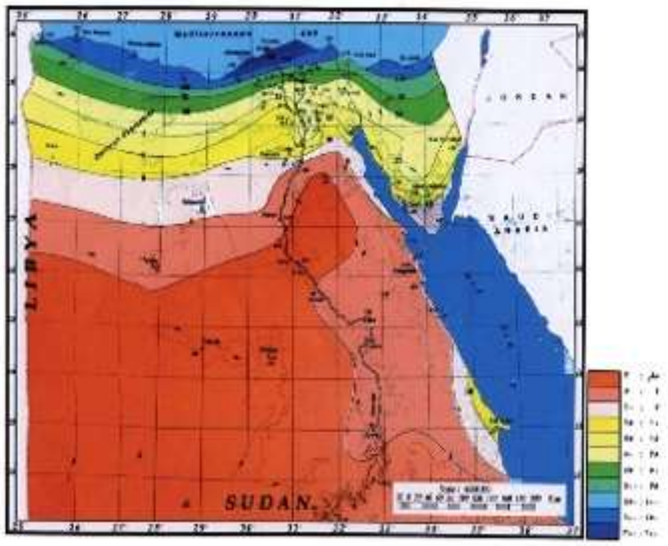

Fig. 5 Mean annual Rain fall over Egypt

Also, data about the maximum temperature, humidity, and wind speed and wind direction were collected. Such data are necessary in the safety assessment of the disposal system because all of them affect the long-term safety of the system. Also, identification of the hydrogeological units, prevailing regime, depth to water and perspective areas from hydrogeological view point were collected together with the 1: 2000000 scale map of Egypt (Fig. 6).

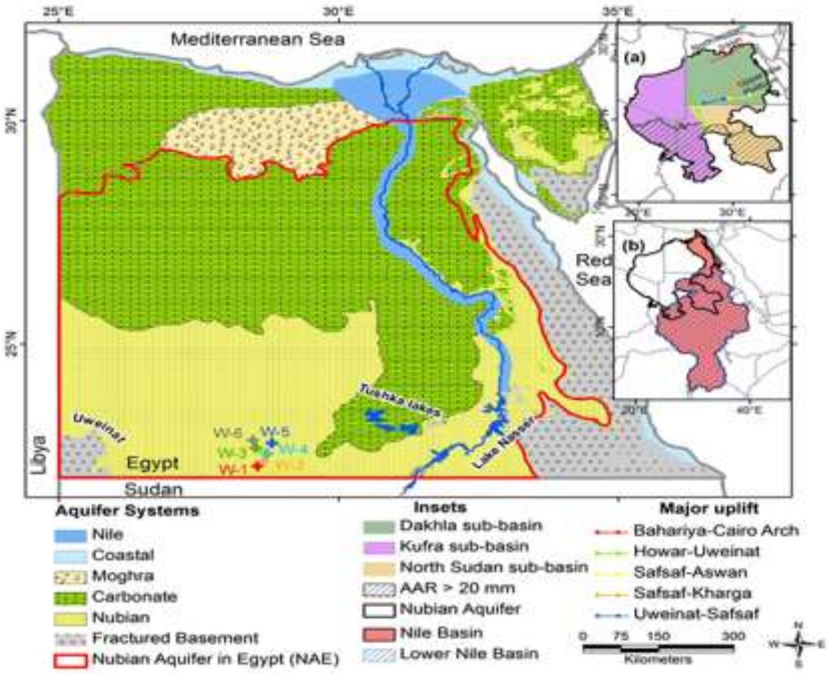

Fig.6 Egypt aquifer groundwater resources. In this study, temporal (April 2002)

Hydrogeological maps of some selected areas like El-Bahariya, El-Dakhla, El-Kharga, Aswan, Nile Delta, Beni Suif, high Dam areas were also considered for more interpretation. Data on the distribution of population in each governorate and the high and low dense areas, the last census were involved. They were carefully investigated and analyzed and then projected on a map showing the governorate in Egypt. To show the impact of the disposal system on the areas of social and economic values information about the oil and mineral occurrence were collected. In addition, the areas of historical importance like natural protectorates have also been identified and projected on a map to be avoided.

PHASE I (EXCLUDED AREAS)

The information needed requires the review of the physical and geological setting of Egypt to define the areas that meet the criteria of exclusion.

PHYSICAL SETTING

Egypt covers roughly a square area of almost 1,000,000 km2 lies at the crossroad of Africa and Asia. It is bounded to the north by the Mediterranean Sea and to the east by the Red Sea. It may be divided into seven main geographic parts namely the Nile Delta and its Valley, Eastern Desert, Western Desert, El-Fayum Depression, the Suez Canal, the Peninsula of Sinai and islands in the Red Sea. To these may be added the marine territorial waters in the Mediterranean, Red Sea and Aqaba Gulf.

The investigation of the map (Fig.5), showing the distribution of mean annual rainfall revealed that, the Northern Mediterranean Coastal Zone of Egypt receives the highest amount of mean annual precipitation ranging between 100 to 300 mm/y and the maximum values are recorded in Alexandria and Rosetta. On the other hand, this rainfall is usually confined to the coast but may extend few kilometers inland. These high values decrease as we go southwards where the low annual amount of precipitation is dominated. The southern parts of Egypt are characterized by low values of mean annual amount of precipitation (0-2mm/y). Although the map reflects the aridity that is characterizing most of Egypt, but this was not the case along the whole geologic history. In the near past, Egypt subjected to pluvial periods that left its pathways and runners in the rocks of mountain areas. In the last few deeades, some parts of Egypt like Sinai, Central part of Eastern Desert and some parts of Upper Egypt which are characterized by the presence of high topography representing catchment areas exposed to heavy rainfall in a short period. In 1994 the catchment areas received high quantity of rain water pushing it to follow the old runners causing flash floods associated with a huge damage in Qaseir and Assuit. So, the candidate sites in such areas should be exposed to detailed studies to define carefully the pathways of the old and recent floods as undue factors affect the overall safety of disposal facility.

The 2017 census was used to define the number of population in each governorate. The distribution of population shows that most population are concentrated in governorates of Delta and its valley. So, the governorates of Cairo Giza, Port Said are characterized by high number of population. The governorates of Alexandria, Fayum, Beni-Suef, Minya, Assiut, Sohag, Qena and Aswan are characterized by intermediate population. The lowest population numbers characterize the governorates of Mars Matruh, Red Sea, and New Valley.

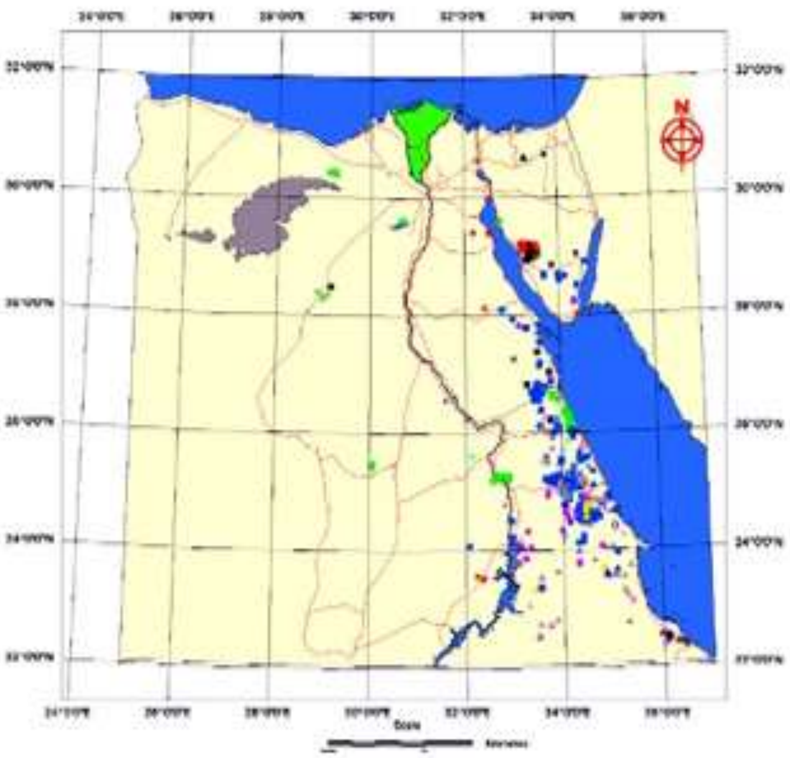

Fig. 7 Mineral Occurrence in Egypt

The socio-economic and political situation of the region has a bearing on deciding upon the location and siting of waste repository. In this regard, for the ready acceptability of such a repository by a society, it is desirable that the site is located in a remote area with low population density and easy accessibility. It should also be ensured that the areas considered are kept out of the purview of mineral and oil exploitation for any foreseeable future. The metallurgical map of Egypt, (Fig.7) shows that most of minerals are concentrated in the southern part of the Sinai Peninsula, the central and southern parts of Eastern Desert, Gebel El-Uweinat in the Western Desert, and the eastern coastal areas of Mediterranean Sea.

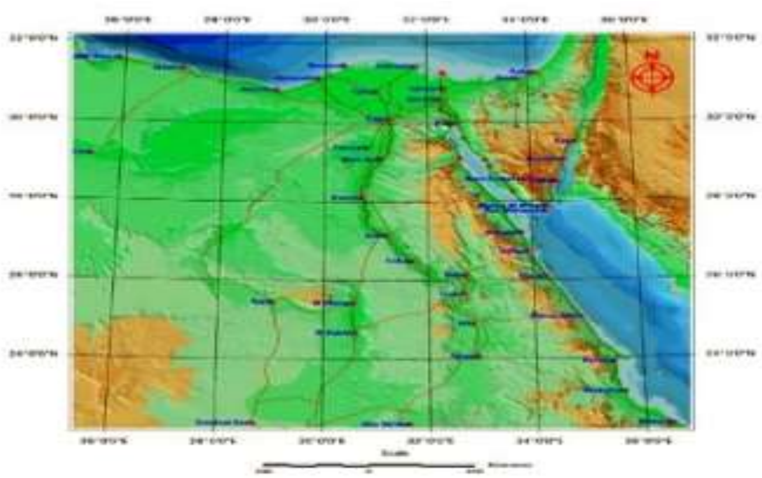

Fig. 8 Topographic Map of Egypt

GEOLOGICAL SETTING

The topographic map of Egypt, Fig.8 reflects that the high topographic areas are represented by the Red Sea mountains, Gebel El-oweinat and the southern part of Sinai peninsula where the outcrops of basement rocks. Also, some areas like east of Cairo and Gulf of Suez district are characterized by moderate topography.

The distribution of earthquake epicenters, Fig.9 suggests that the earthquake activity occurs along three main seismic trends; (1) Northern Red Sea. Gulf of Suez – Cairo – Alexandria Clysmic trend, (2)

East Mediterranean – Cairo, Fayum, Pelusiac trend,(3) , Levant. Aqaba trend. In addition to these trends, there are several areas known to be active such as southwest of Aswan, Abu Dabab, Gilf El – Kebir and Wadi Hagul west of Gulf of Suez (Kebeasy 1990). This map shows also that the high tectonic and high seismicity regions are the southern part of Sinai, the area along the Aqaba Gulf and the Red Sea at the entrance of Gulf of Suez. Maximum Intensity values of VIII are expected in the sector section of the Red Sea and southern part of Sinai Peninsula, (Riad, 1990).

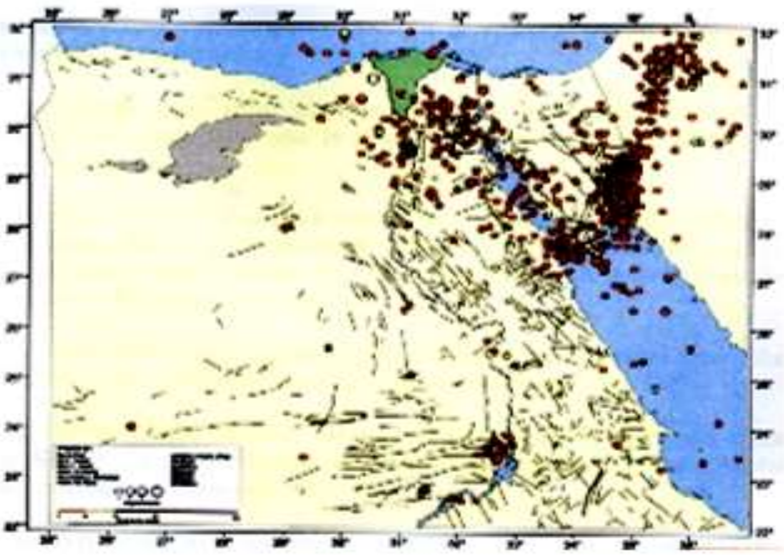

Fig. (9): Seismicity Map of Egypt

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EXCLUDED AREAS

Based on the fore-mentioned discussion, it could be concluded that both the peninsula of Sinai, Nile Delta and its Valley and areas of historical value should be excluded from our concern as potential areas for radioactive waste disposal in Egypt. Regarding Sinai Peninsula:

- Its critical political situation, high tectonic and high seismicity, especially the regions restricted between the two gulfs and those extending along the Gulf of Aqaba.
- With potential for flooding, especially in the northeast part.
- Areas of oil and mineral exploration,.
- Areas of projected cultivated projects after the extension of El-Salam canal in the Northern Sinai.

On the other hand, Nile Delta and Nile Valley should be excluded due to

1. Their high population density.
2. Shallow depths to water.
3. And very important for present and future projects.

PHASE II (SITES MEET PRIMARY CRITERIA)

Potential sites should characterize by the primary criteria that mentioned above. Three maps have been established to define sites that meet primary criteria. These maps are the one that shows the average annual rainfall, the distribution of alluvium deposits and the depth to water map.

AVERAGE ANNUAL RAINFALL

The map showing the average annual rainfall was prepared by the Egyptian meteorological authority in 1996. This map reveals that the northern Mediterranean coastal zone of Egypt receives the highest amounts of mean annual amount of precipitation ranging between 100-300mm, and the maximum values are recorded in Alexandria and Rosette. On the other hand, this rainfall is usually confined to the coast but may extend few kilometers inland. These high values decrease as we go southward where the low annual amount of precipitation are dominated. The southern parts of Egypt are characterized by low values of mean annual amount of precipitation (0-2mm).

Fig.10 Shows the out crops of Geological units over Egypt

DISTRIBUTION OF ALLUVIUM DEPOSITS

Alluvium deposits belong to more than one geologic epoch in Egypt. In the following a description of their nature, localities and thicknesses according to the available data will be given.

Oligocene sediments

The Oligocene was mostly an epoch of erosion in Egypt. The most pronounced unconformity in the sedimentary section in the Gulf of Suez and north Egypt belongs to that age. The exposed sediments of the Oligocene are in the form of sands and gravels of fluvial or estuarine origin with remnants of fossil plants and large animals which crop out along a strip bordering the footsteps of the elevated lands of Egypt, extending from Suez to western tip of Qatara depression. These fluvial outcropping sediments are well sorted and well-rounded sand which have been derived from the sandstone to the south. A fan of Oligocene deposits spread out between the north western tip of the Fayum depression and Mughra , in the northeastern Qattara depression (Abu-A1-izz, 1971). To the north of that strip, the Oligocene becomes buried under the Miocene and younger sediments and becomes finer- grained sand of marine character (Said, 1990).

In the Gulf of Suez and Red sea regions, as well in the Cairo Suez district, Oligocene sediments are either continental or entirely missing. In the Qoseir- Safaga area near the Red Sea coast, the southernmost continental sediments, which are probably of Oligocene age, were deposited in local basins. These sediments are about 149 m thick and consists of conglomerate with sandstone and shale incorporating thin limestone intercalations (E1-Akkad and Dardir, 1966; Issawi et al., 1971). The well Known Oligocene continental sediments at Gebel E1-Ahmar, in the vicinity of Cairo and in the Cairo- Suez district are mainly ferruginated sands, sandstones and quartzites(Farrag and sadek, 1966).

Continental conditions prevailed around the latitude of Cairo and to the South. This lithology is interrupted by delta deposition (Gebel E1-Qatrani sediments) west of the River Nile (Beadne11, 1905). El- Shazly et al. (1974) divided the 170 m thick

Gebel El- Qatrani sediments, best developed at widen E1- Fares into lower sandy, middle clayey and upper sandy members, deposited by a river system originating in what is now the Eastern Desert, and with material coming in the earlier Oligocene from southeast and in the later Oligocene from the northeast.

In the northern western Desert, the deltaic environment gives way to marine conditions, the Late Eocene to Late Oligocene marine section is largely shale and reaches 580 m in thickness (Marzouk, 1970).
Miocene sediments.

The Miocene sediments are mapped as what is known as the Mughra Formation which is traced along the northern margin of the Qattara Depression as very thick sand and mud deposits of fluvio¬marine origin. The thickness of this formation is about 400m (Abu¬A1-Izz, 1971).

The deepest borehole in the Nile Delta encountered 931 m of the middle Miocene Sidi Salem Formation. which consists of shales becoming sandy southward and enclosing dolomitic limestones. A marine environment is reported for the Middle Miocene in the Delta (IEOC, 1970).

Along the eastern side of the Gulf of Suez and along the Red Sea coast, the Miocene sediments are thick and composed of gypsum and anhydrite with layers of sandy loams. Their thickness varies from place to place. It is about 700m at Gebel Hammam Faraon while elsewhere, it is only some tens of meters. These formations are deposited in the water of coastal lagoons.

Pliocene sediments

- Along the Nile Valley, in the vicinity of Aswan, Chumakon (1967, 1968) described three series of Late Pliocene Early Pleistocene sediments. The oldest series consists of clay with sand lenses at-172, to - 35 absolute level and deposited in marine to estuarine environment. The middle series belongs to regression phase and deposition occurred in a fresh water basin. It consists of sands, sandy loams and gravel intercalated with clay lenses at +7 to + 116 m absolute level. The upper series is made up of alluvial gravels at+ 166. To + 200m absolute level.

Under the present Nile Delta, thick Pliocene strata including the Lower Pliocene Abu Madi Formation of sand with shale were deposited in a shallow marine environment. The Pliocene Kafr El-Sheikh Formation, which is essentially marine shale although partly fluvio-marine is followed upward by the upper Pliocene El-Wastani Formation constituted of estuarine to fluviatile sand and shale (IEOC, 1970).

At El-Qantara in the northern part of Suez Canal zone, El¬Shazly et al., (1970) found Late Pliocene sand and clay considered as an extension of the Pliocene of the Nile Delta to be below Quaternary sediments.

Pliocene sediments of fluvial origin are being deposited at the mouths of the Eastern Desert wadis (at their point of confluence with the Nile) with few meters thickness. The materials are primarily sands and gravels and their elevation 180 asl. They extend along both sides of the Nile Valley in the locations where erosion was not strong enough to remove them (Abu-Al-Izz, 1971).

In the Gulf of Suez, Pliocene and younger sediments encountered in the subsurface may reach a thickness of 500 m. The sediments are generally marine in the south and are usually constituted of fluvial or other continental gravels and sands in the north (Khalil, 1975). In the Cairo - Suez district, Pliocene deposits including gravels, sands and limestone have been encountered and appeer to have been deposited in environments ranging from continental to shallow marine (Shukri and El- Ayouti 1956).

Quaternary sediments
Ball (1939) divided the Quaternary sediments as Follows:

- Raised beaches and coral reefs along the coast of the Red sea.
- Oolitc limestone on the Mediterranean Sea. Alluvial deposits in the Nile Valley and the delta.
- Lacustrine deposits and Nile mud in El- Fayum Deperession.
- Alluvial deposits in the drainage channels and depressions of the desert and on the coastal plains.
- Calcareous tufa in the oases of E1- Kharga and Kurkur and dunes and other accumulations of wind-borne sand.

Concerning the Quaternary sediments along the Nile valley and Delta, Said, (1981) classified such deposits into; Protonile Penile Q2 and Neonile Q3 episodes. Each of these episodes is characterized by a master river system. Toward the end of each of the first two episodes (the last is still extent) the river seems to have declined or ceased entirely to flow to Egypt. The recognition of the deposits of these rivers makes possible the division of the Pleistocene of the Nile into a threefold system. The deposits of each of these rivers are distinct in lithologic, stratigraphic relationships and mineral content.

Deep drilling in the peresnt Nile Delta has contributed greatly to our understanding of the Quaternary of geology of this area and is summarized as follows (El-Sherbini 1973 and said, 1981). The fluvio- marine Mit Ghamr Fm. of Upper Pliocene to Quaternary, is constituted of sand with clay beds attaining a maximum thickness of 852 m in sidi salem well No. 1. While, thinning northward and southward. The Bilqas Fm. is Quaternary and consists of clayey sand which thickens from 4.4m at shibin El-Kom in the southern delta to 60.5 m northward in Rosetta offshore well No.2. El- Shazly, (1975) studied the Quaternary sediments at E1- Qantara in the northern suez canal zone as revealed in shallow boreholes and noted the strong similarity to the Quaternary sediments of the Nile Delta. At zug El¬Bohar (Red sea coastal zone), the thickness of Pleistocene sediments is about 110 m. They are represented by a shelly coralline, Limegrit facies with sandy, algal biomicrite indicating deposition under a fairly shallow, reefal, marine environment with access to abundant detrital material from land.

Quaternary Sediments of deserts
Due to the prevalence of aridity, the Quaternary sediments of Egyptian deserts could be summarized as follows:

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Eolian deposits (Sand dunes)

Sand dunes cover a large part of the surface area of Egypt. The Western Desert is only characterized by the occurrence of large sand dunes that covered about 40% of its area and is known as the sand sea. It represents the largest dune which extends from the southern boundaries of Siwa oasis to the southern borders of Egypt and north Sudan. Thickness of such dunes may reaches tens of meters but never exceeds 100 meters. The Abu Muharik dune belt is another conspicuous belt in the Western Desert. It extends for a distance of 300 km in length and only a few kilometers in width from west Baharia Oasis to the north end of kharga and continues with minor breaks and nearly in the same direction for another 150 km within kharga depression. Dunes move at rates that have been variously estimated from 10 to 100 m per year (Embabi, 1982).

Fluvial deposits (Sand Sheets):

The southern part of the Western Desert sand sheets of fluvial origin represents the relics of complex drainage system. They probably represent deposits of braided streams which spread from the highlands to the south and west. The upper 20 to 50 m are made up of unconsolidated lamination to medium to coarse grained sand. These rest over layers of slightly more consolidated sand. Drilling and recent seismic work indicate that beneath these layers, there is a 50 to 200m thick layer of indurated and weathered coarse - grained sand grading into gravels (Said, 1982). The selima sand sheet covers an area of 4000 km' in the southwest of Egypt and north Sudan.

HYDROGEOLOGICAL ASPECTS

The investigation of hydrogeological map of Egypt indicates that the groundwater in Egypt belongs to three main aquifers. The Quaternary aquifer which is fresh water and it is under free water table conditions. Quaternary deposits cover most of Egypt but they differ in lithology from place to place. They are represented by raised beaches and coral reefs along the coast of the Red Sea, oolitic limestone on the Mediterranean sea, alluvial deposits and Nile mud in El-Fayum Depression, alluvial deposits in the drainage channels and depressions of the desert and on coastal plains and calcareous tufa in the Oases of El –Kharga and Kurkur and dunes and other accumulations of wind-borne sand (Ball, 1939). This lithological content has its impact on the quantity and quality of Quaternary aquifer. Miocene aquifer which is semi-confined aquifer and contains saline water. The Miocene sediments are mapped as what is known as the Mughra Formation which is traced along the northern margin of the Qattara Depression as very thick sand and mud deposits of fluvio-marine origin. The thickness of this formation is about 400m (Abu-Al-Izz, 1971).

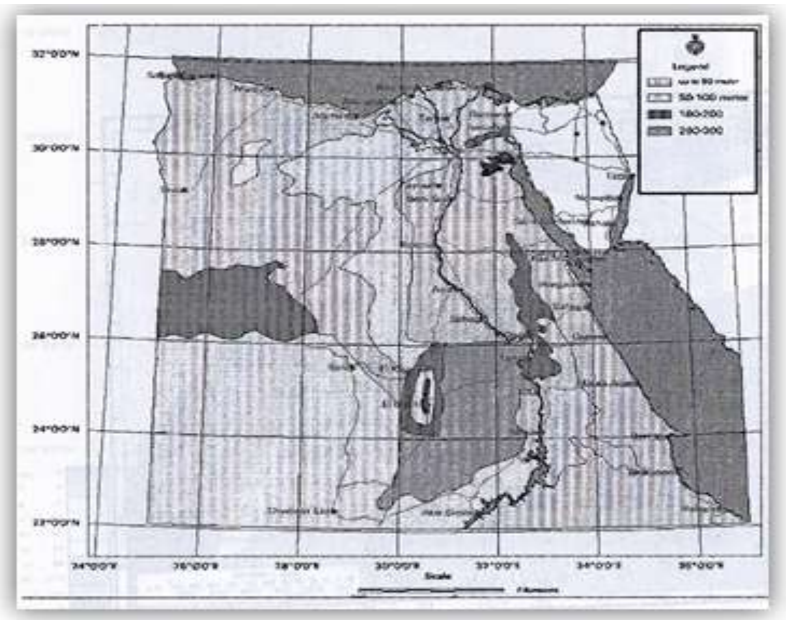

Fig.11 Depth to water of Egypt

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Also, the Miocene sediments are represented in the Nile Delta by 931m of the Sidi Salem Formation. Along the Eastern side of the Gulf of Suez and Red Sea coast, the Miocene sediments are thick and composed of gypsum and anhydrite with layers of sandy loams. The Nubian sandstone aquifer which occupies the most parts of Western Desert, some parts in the Eastern Desert and Sinai Peninsula. It represents the main and productive aquifer in the Western Desert and extends to great depths reaching more than 1000m in some localities where groundwater exists under high artesian conditions. The upper most layer represents a free aquifer with shallow depth to water. In some depression (Oasis) of western desert as El-Kharga, El Dakhla, El-Farafra, El Bahariya and Siwa, flowing water conditions exist.

All available hydrogeological data were used to establish a depth water map (Fig.11).These data are represented by hydrogeological map developed by water research institute and previous hydrogeological studies. Based on the examination of such data and the constructed depth to water map, the following can be noticed.

1. The depth to water in the Nile Valley and its Delta is shallow. It ranges from 0-Sm in the Nile Delta and 5-15 m in the Nile Valley.
2. In the Eastern Desert, the thin layer of wadi deposits that overlie the basement rocks at the central and southern parts represents the main aquifer beside the scattered fractured zone of basement complex. Depth to water in these two types is shallow with maximum depth of 20m. On the other hand, the groundwater exists at much greater depths in the northern part of the Eastern Desert between Nile Valley and Gulf of Suez.
3. The main and high productive aquifer in the Western Desert is the multi-layered Nubian Sandstone aquifer, extends to great depth reaching more than 1000m in some localities where groundwater exists under high artesian conditions. The upper most layer represents a free surface aquifer (unconfined) with shallow depth to water. In some depressions of Western Desert (Oasis) as El-Kharga, El-Dakhala, E1-Farafa, El¬Baharia and Siwa, flowing

POTENTIAL AREAS USING GIS APPLICATION

One of the most important applications of the Geographic Information System is its uses as a tool in defining the ideal exploitation of land after preparing a model containing the data needed and conditions required in the concerned sites. So, all the fore-mentioned information were entered to the computer in the form of different layers to represent the input file for the GIS running. These layers include seismicity, groundwater, population, mineral occurrences, natural protectorates and roads. The GIS software has been applied and the output is in the form of a map showing potential areas as seen in Fig.12.

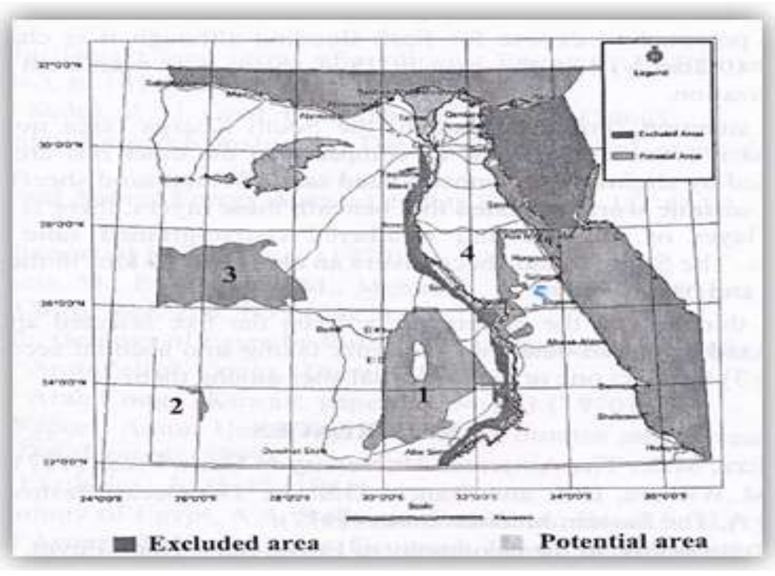

Fig.12 Excluded and potential areas

Potential sites

Sites that meet primary criteria in Egypt are:

1. East of Kharga.
2. South of Kharga.
3. Great sand sea.
4. Gilf El-Kebeer plateau.
5. The central part of Eastern Desert (wadi Qena).

CONCLOUGN

IAEA developed an approach to use by its member states in site location of radioactive waste disposal repositories. This approach is associated with difficulties in its application manually. MM is a modified method in which the site survey stage is divided into three phases, and GIS multi criteria concept has been used. MM is characterized by easy used, fast and save time. MM is applied to locate suitable sites for disused radioactive sealed sources in Egypt. Five sites have been selected meeting the primary criteria.

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