Egyptian Geophysical Society
EGS Journal, vol. 2, No. 1, 197-206 (2004)

GEOLOGICAL AND ENVIRONMENTAL CONSIDERATIONS FOR RADIOACTIVE WASTE DISPOSAL IN EGYPT

M.A.H. Abdel Aziz, F.S. Tawfik, and A.H.Attia,

Siting & Environmental Department, National Center for Nuclear Safety & Radiation Control, Atomic Energy Authority

الاعتبارات الجيولوجية والبيئية في اختيار مواقع دفن النفايات المشعة بمصر

الخلاصـــة: نتيجـة للاسـتخدامات السـلمية للنظـائر المشـعة علـى نطـاق واسـع فـي مصـر تتراكم كميـات مـن النفايـات المشـعة ذات المسـتويات المنخفضـة والمتوسطة والتي ينبغى أخذها في الاعتبار حماية للإنسان والبيئة، ويعد دفن النفايات المشعة في التكاوين الجيولوجية أحد أهم الوسائل المستخدمة للتخلص من تلك النفايات والتى تضمن عزل نظام الدفن عن الغلاف الجوى شريطة أن تتفق الخصائص الفيزيائية والجيولوجية للموقع والمعايير الملزمة من قبل الوكالة الدولية للطاقة الذرية. وتهدف هذه الدراسة الى استخدام نظام المعلومات الجغرافي لتحديد بعض المناطق الملائمة لبناء مقبرة لدفن المخلفات آخذين في الاعتبار بعض العوامل الإقليمية مثل النشاط الزلزالى والتكتونى والكثافة السكانية وتواجد المياه الجوفية والمعاملات المناخية مثل احتمالات حدوث الفيضانات ونسبة الرطوبة وقيم درجات الحرارة الصغرى والعظمى ومعدل سقوط الأمطار بالإضافة على التأثيرات الاجتماعية والاقتصادية.

وقد بينت هذه الدراسة أن أقاليم مثل وادي النيل ودلتاه وشبه جزيرة سيناء بالإضافة على المناطق ذات الميراث التاريخى يجب أن تستبعد من دائرة الاهتمام كمواقع لدفن المخلفات المشعة، بينما تعد الأجزاء المتبقية من مساحة مصر والممثلة في كل من الصحراء الشرقية والغربية ومناطق ملائمة من وجهة نظر العوامل السابقة لإجراء مزيد من الدراسات لاختيار أنس مواقع ملائمة بها وتقييم الأمان وأداء نظام الدفن على المدى الطويل بالموقع.

ABSTRACT: *Disposal of radioactive waste in geologic environment is considered the most practical way to ensure the isolation of the disposal system from the biosphere on condition the site has characteristics that meet the criteria and regulations posed by the International Atomic Energy Agency (IAEA). In Egypt considerable amounts of low and intermediate levels of radioactive wastes are accumulated due to the peaceful uses of radio-isotopes. This study aims at the use of the Geographic Information System to locate some potential areas for receiving a repository for disposal the low and intermediate levels of radioactive waste in the Egyptian territory taking into account the regional aspects like: seismicity, potential for flooding , population density, hydrogeology and socio-economic impacts. Based on the geological and environmental settings of Egypt, the Nile Delta and its Valley, Sinai Peninsula and areas of historical heritage value are excluded from our concern as potential areas for radioactive waste disposal. The other rest parts of Egypt that represented by the Eastern and Western Deserts are considered potential areas for receiving much attention and studies in order to select favorite sites and to predict the long term performance of the disposal system.*

INTRODUCTION:

Sites proposed as repositories for radioactive waste disposal should be subjected to detailed studies, including the meteorological, geological, geophysical, hydrogeological and geotechnical aspects. The main purpose of such studies is to ensure that the disposal system will be completely isolated from the biosphere. This couldn't be realized unless both the geological and engineering barriers are integrated together to prevent the arrival of any radionuclides leaching from the disposal system to the biosphere in a worse condition. To recognize such a kind of high level of safety. regional data and studies should be conducted to select one or more areas as potential ones for radioactive waste disposal.

In this work, the regional criteria namely seismicity, potential for flooding, mean annual rainfall, maximum temperature, population density, topography and socio-economic impact are taken into account to define the potential areas for radioactive waste disposal.

IAEA GUIDELINES

IAEA posed criteria and regulations that govern the siting of low and intermediate levels of radioactive waste disposal (IAEA, 1994). These regulations must be strictly followed by the member states to recognize the required safety protecting man and its environment from the undue consequences and the isolation of the disposal system from the biosphere. These regulations could be summerized as follows;

- The geological setting at the site should contribute to the isolation of waste and limitation of release of radionuclides to the biosphere.
- The hydrogeologyical setting of the site should include low groundwater flow and long flow paths in order to restrict the transport of radionuclides.
- The geochemistry of groundwater and the geological media should contribute to limiting the release of radionuclides from disposal facility.

- The site should be located in an area of low tectonic and seismic activity such that the disposal capability of the disposal system will not be endangered.
- Surface processes such as flooding, landsliding or erosion should not occur with such frequency that they could affect the ability of the disposal system to meet safety requirements.
- The site-area meteorology should be characterized such that the effect of unexpected extreme meteorological conditions can be considered in the design and licensing of the disposal facility. Consideration should be given to the following conditions; precipitation (rain and snow), dispersion conditions for potential atmospheric releases, potential for extreme weather phenomena such as tropical and extratropical cyclones, tornadoes, severe winter storms and sandstorms.
- The site shall be located such that activities present or future generations at or near the site will not affect the isolation capability of the disposal system.
- The site shall be located such that the access routes will allow transportation of waste with a minimal risk to the public.
- Land use and ownership of land should be considered in connection with foreseeable development and regional planning in the area of interest.
- The site should be located such that the potential hazard of the disposal system on the current population and projected future population is acceptable.
- The site shall be located such that the environment will be adequately protected during the entire lifetime of the facility and such that adverse impacts can be mitigated to acceptable degree.

REQUIRED DATA

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. Seismological data in the form historical and instrumental earthquakes that affected Egypt along its recent geological history has been acquired. This data will help in defining the major seismo-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 (EMA, 1997). Also, data about the maximum temperature, humidity, 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 regim, depth to water and prespective areas from hydrogeological view point were collected together with the 1 : 2000000 scale map of Egypt. 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.

RESULTS AND DISCUSSION

Egypt covers roughly a square area of almost 1,000,000 km^2 lies at the crossroad of Africa and Asia, Fig. (1). 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 topographic map of Egypt, Fig.(2) 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.(3) 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 northern section of the Red Sea and southern part of Sinai peninsula, (Riad, 1990).

The investigation of the map (Fig.4), 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,

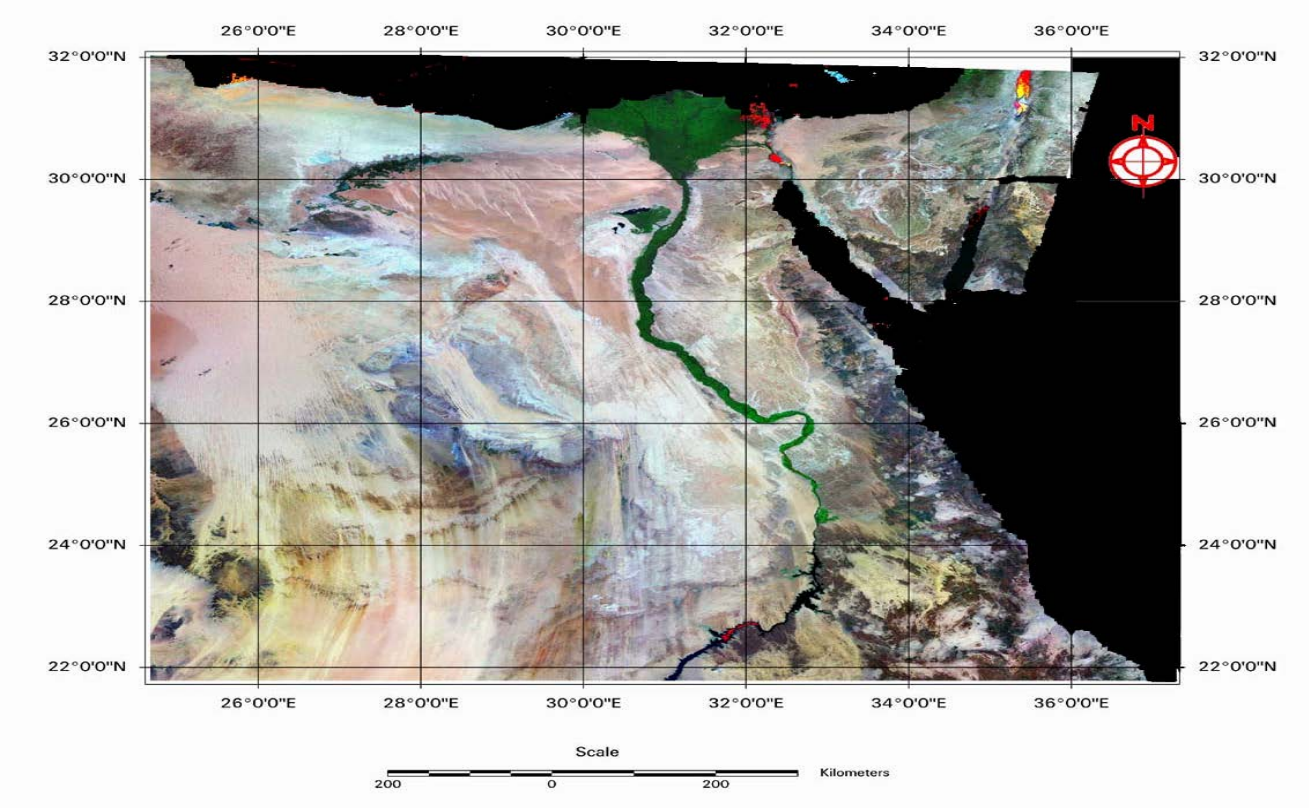

Fig. (1): Geographic Map of Egypt

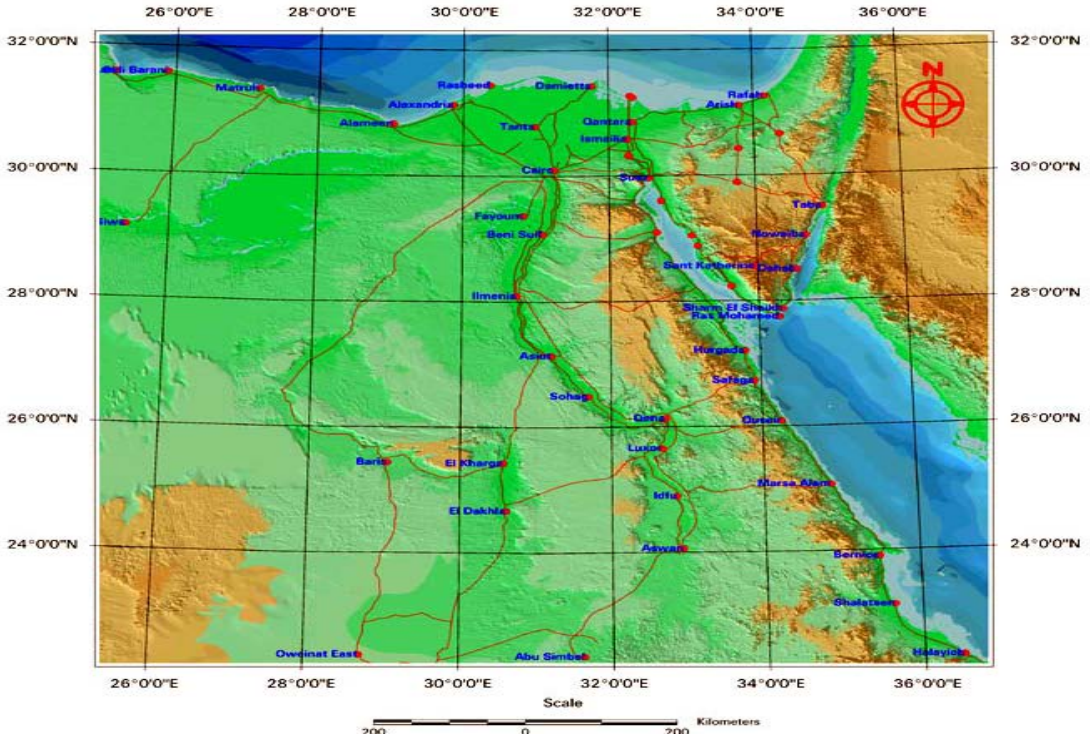

Fig. (2): Topographic Map of Egypt

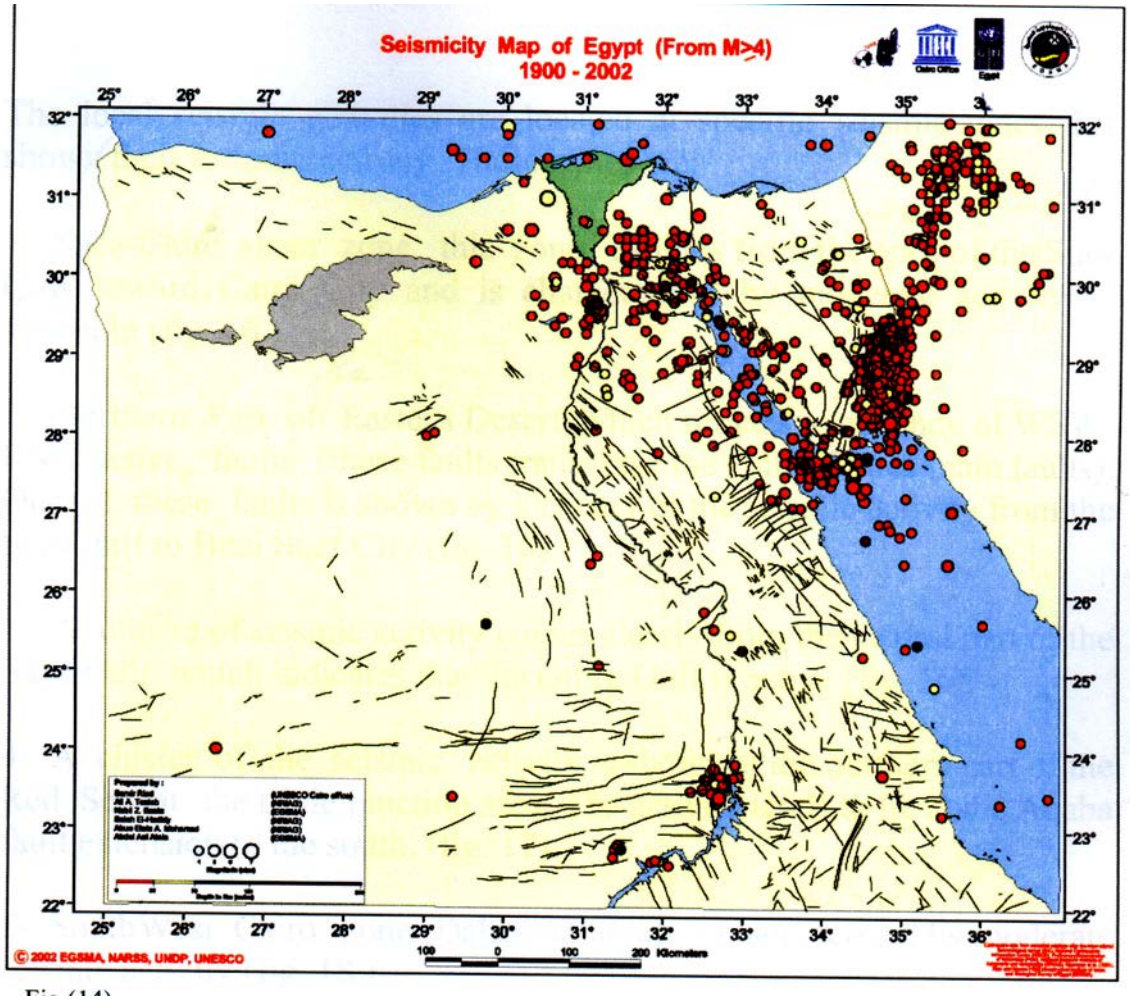

Fig. (3): Seismicity Map of Egypt

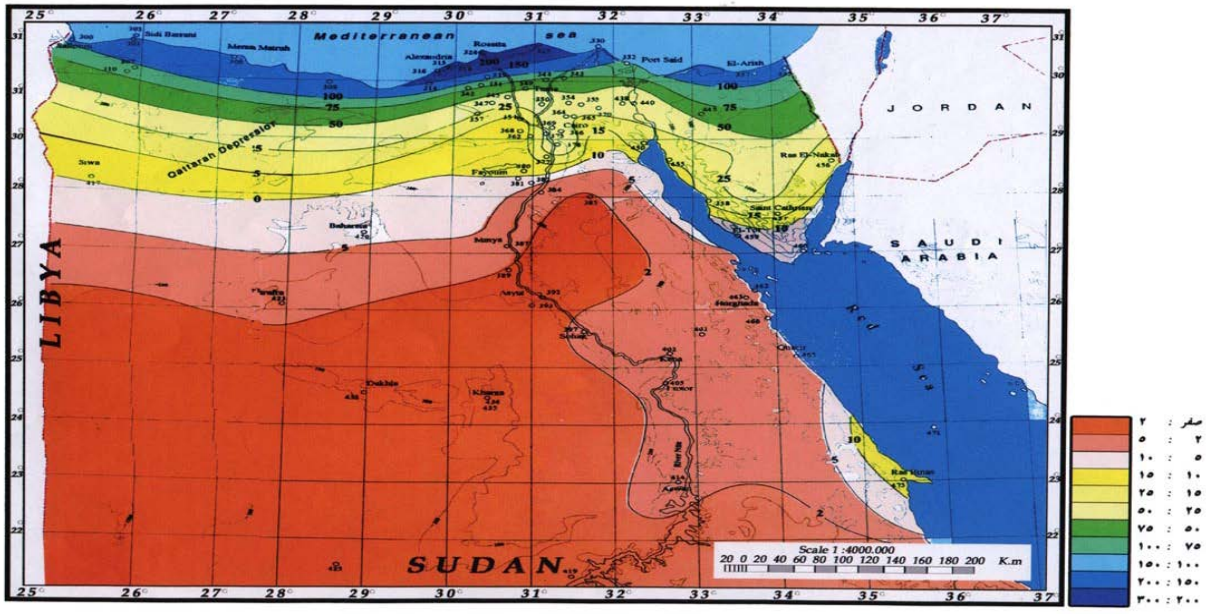

Fig. (4): Mean Annual Precipitation Map of Egypt

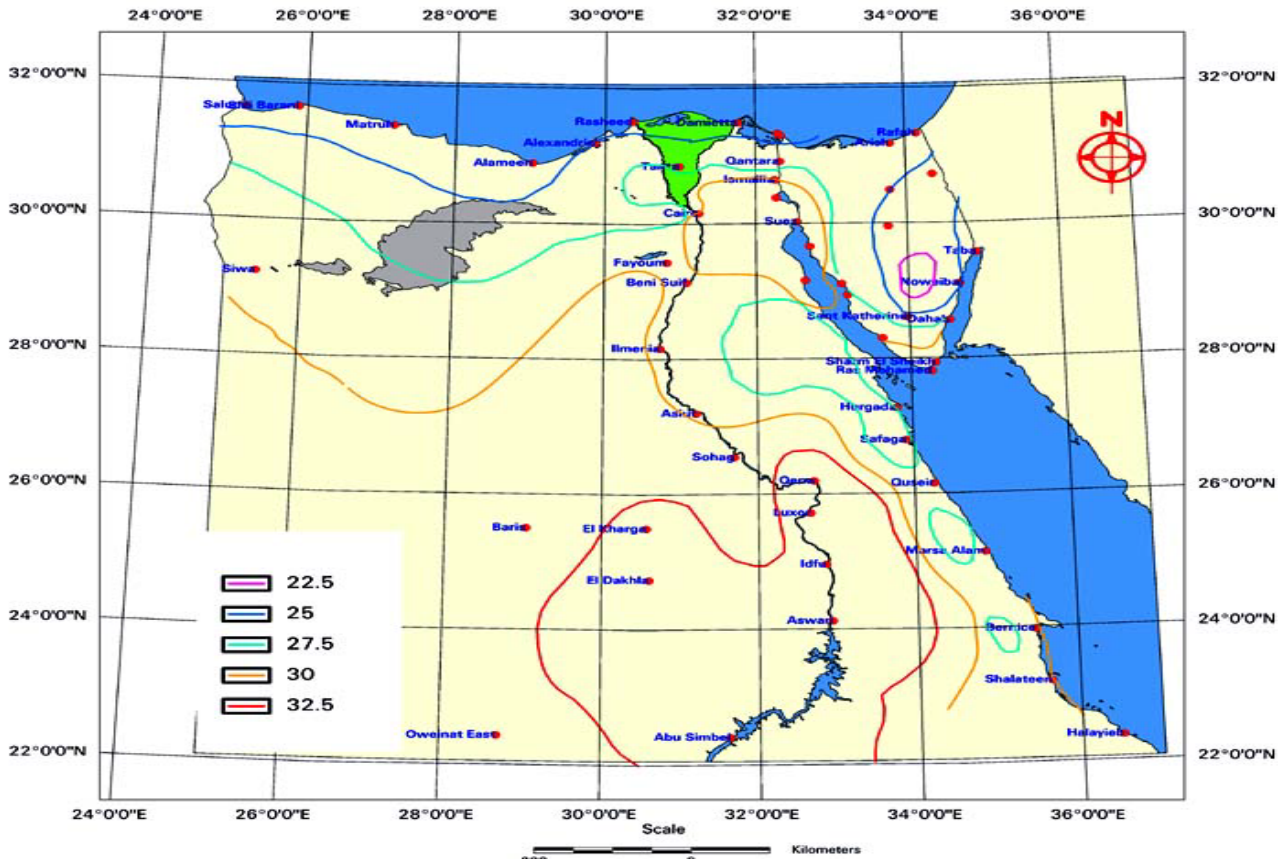

Fig. (5): Mean Annual Maximum Temperature Distribution Map of Egypt

this rainfull 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). Although the map reflects the aridity that is characterizing most of Egypt, but this was not the case along the whole geologic historty. 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.

Also, the investigation of distribution of maximum temperature map as seen in Fig (5) shows that the maximum temperature values are recorded in the southern part of Egypt . On the other hand, the higher humidity values are recorded in the northern and eastern parts of Egypt where the water bodies are located. These meteorological parameters are very important and should be considered in site selection as factors affecting the degradation of the repository. Hence, they should be considered in the overall safety assessment of the disposal system.

The 1996 census was used to define the number of population in each governorate and the results are projected on a map as shown in Fig.(6). Studying this map 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.

The investigation of hydrogeological map of Egypt Fig.(7) 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

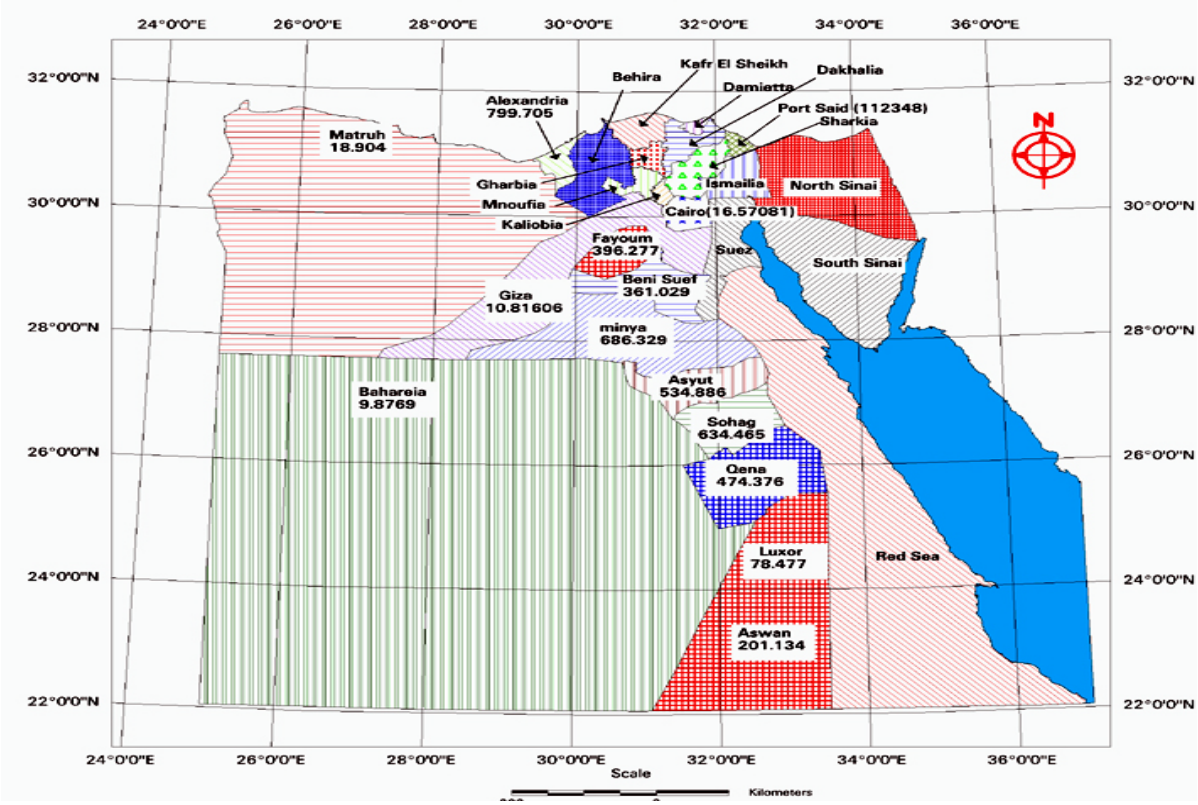

Fig. (6): Population Distribution Map of Egypt

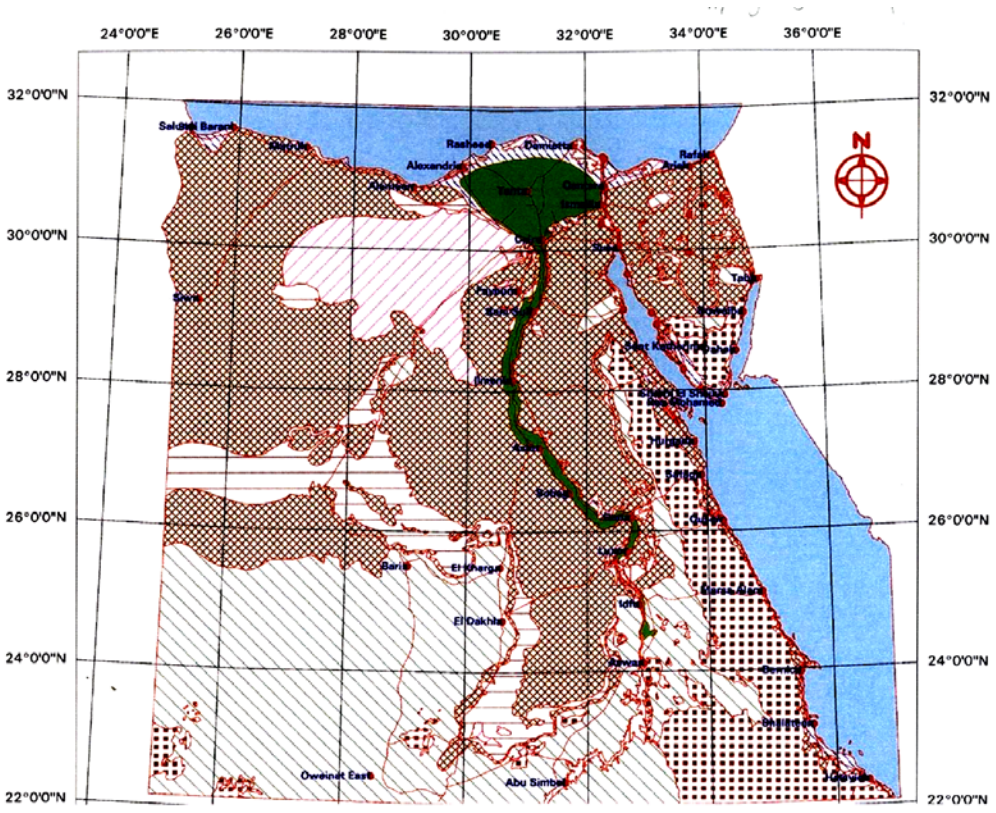

Fig. (7): Hydrogeological Map of Egypt

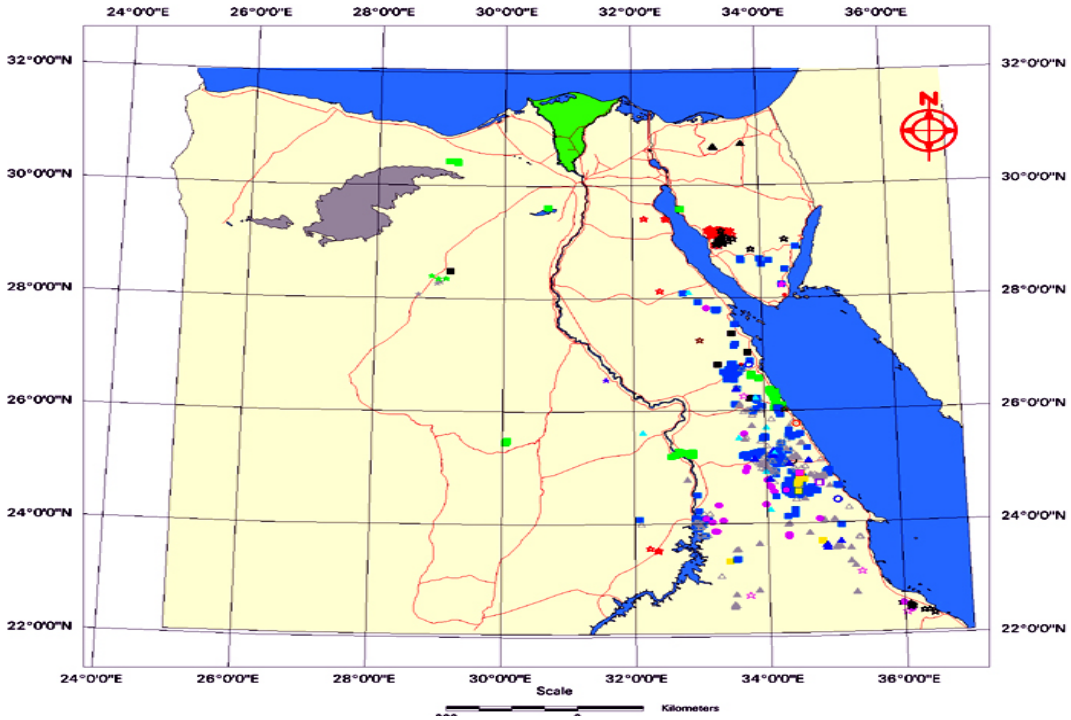

Fig. (8): Distribution of Mineral Resources in Egypt

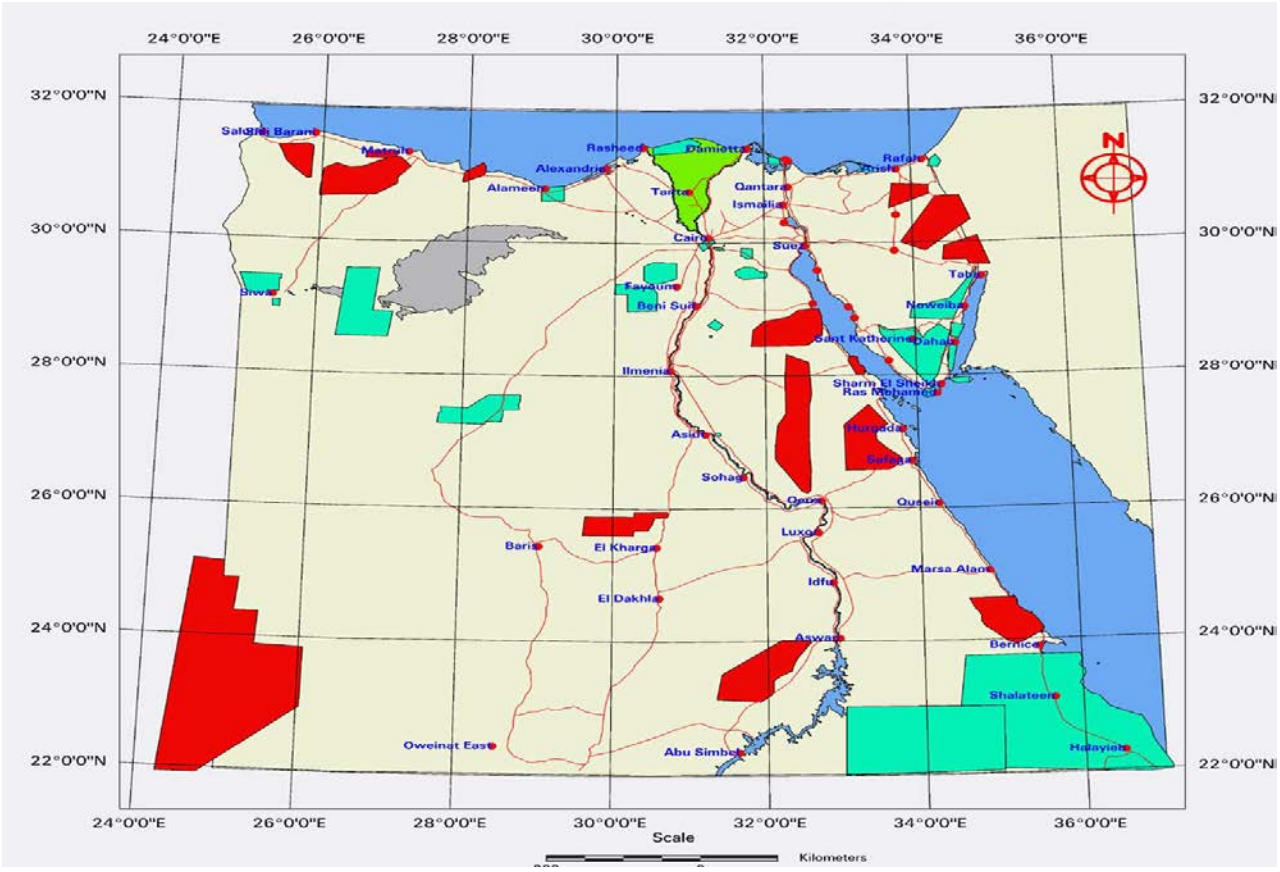

Fig. (9): Distribution of Natural Parks in Egypt

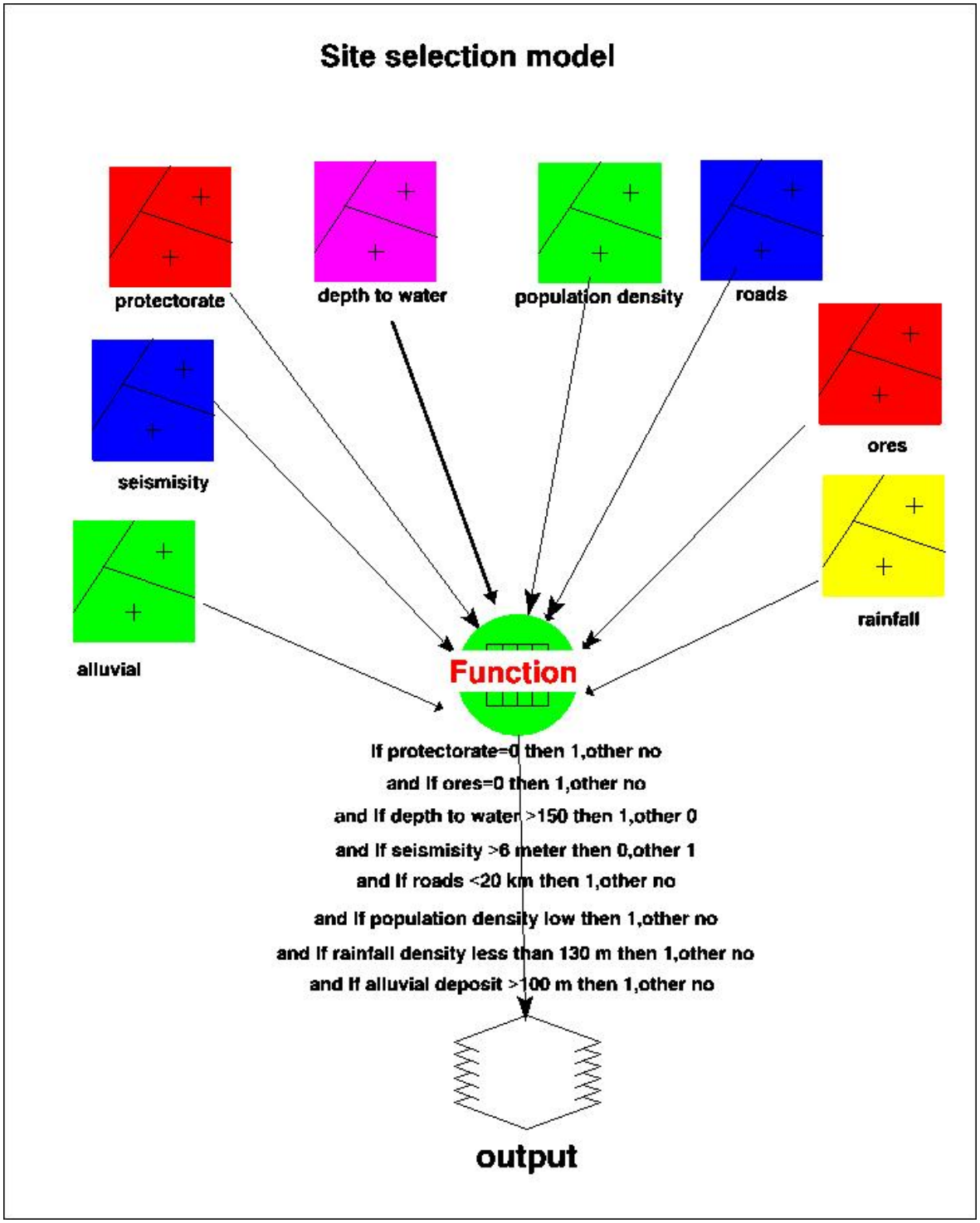

Fig. (10): Site Selection Model

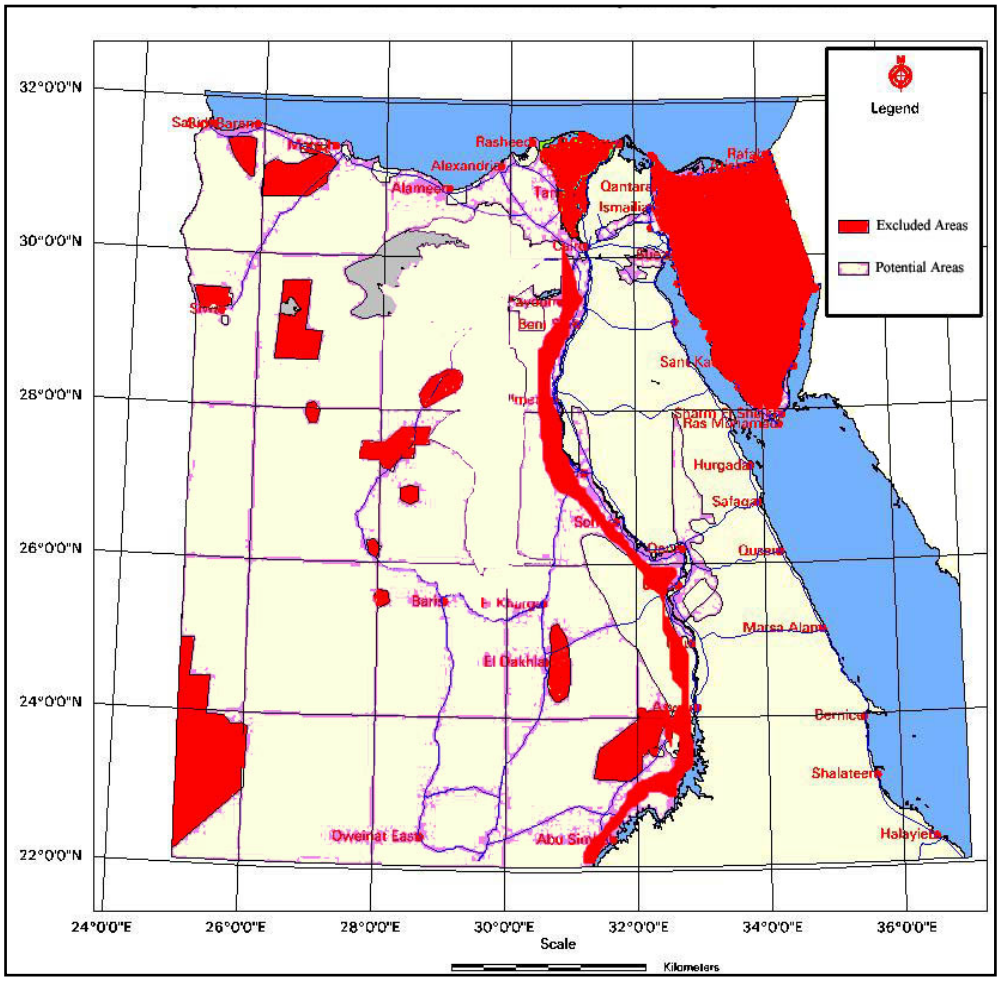

Fig. (11): Potential Areas for Radioactive Waste Disposal Using GIS Software

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). 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.

The socio-economic and polilical 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 repositiory 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 (8) 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.

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 as shown in Fig.(9) 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 (Fig. 10) showing the excluded and potential areas.

CONCLUSION

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 different radioactive waste disposal in Egypt for reasons. Sinai peninsula has its eritical 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 their high population density, shallow depths to water, and very important for present and future projects.

Potential Areas

The rest parts of Egypt that are represented by both the Eastern and Western Deserts could be considered as a candidate and potential areas for receiving much detailed studies for selecting a favorite sites and predicting the long term performance of the disposal system.

REFERENCES

Abu Al-Izz, M. S. 1971: Landforms of Egypt. The American Univ. In Cairo Press

Alan E. M.,William H. K. And Francis G.S. 1977: The Ocean Basins and Margins. Vol. 4A, the Eastern Mediterranean.

Ball, J. 1939: Contribution to the Geography of Egypt. Egypt Surv. Dept. 300pp.

CAPMS, 1996: Population Estimates for 1996. the Centeral Agency for Public Mobilization and Statistics, Dec, 1998.

CAPMS, 2004: Population Estimates for 2004. the Centeral Agency for Public Mobilization and Statistics, Dec, 1998.

EMA, 1996: The Climatic Atlas of Egypt. Egyptian Meteorological Authority, Cairo, Egypt 1996.

EGSMA, 1994: Flooding. Ministry of Industry and Mineral Resources, The Egyptian Authority for Geological Survey and Mining Resources.

IAEA, 1994: Siting of Near Surface Disposal Facilities. safety series no. 111-G-3.1, International Atomic Energy Agency, Vienna, 1994.

Kebeasy, M. R. 1990: Seismicity of Egypt. In Geology of Egypt by Rushdy Said, chapter V, pp 51-60.

Riad, S. 1999: Earthquake Hazard Assessment in the Southern Part of the Western Desert of Egypt. Final report, Assiut University, Center for Studies and Research for South Valley Development.