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INTEGRATED GEOTECHNICAL AND RADIOACTIVE DATA FOR SITE SELECTION OF URBAN EXTENSION AT NEW ALAMEIN CITY, EGYPT

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ABSTRACT

The main objective of the present study is to build a spatial model of the geotechnical properties and radiometric measurements for site selection of urban extension at the study area by using geographic information systems (GIS) techniques to develop and analyze a site model and also to make sound decisions and to plan site activities at the New Alamein City. In the geotechnical site evaluations and radioactive measurements, GIS can be used in four methods, data integration, data visualization and analysis, planning and summarizing site activities, and data presentation. The integrated data can be displayed as contour maps; manipulated and analyzed using tools built into the GIS programs, thus creating the geotechnical and radioactive site model of the study area. Explanation of these data needs the spatial location to integrate into the analysis. Mechanical and physical properties of the soil, chemical analysis, and radioactive data are weighted. Finally, the weighted maps are integrated using a GIS based on the construction purposes for the new extension of New Alamein City for note worthy cost savings in design, construction, and long life. The very high and high zones highest regime has been observed towards the most of the study area but the moderate zones are observed toward the northern side of the area and the low is the smallest zone toward the southern side of the study area.

INTRODUCTION

The urbanization is known as the transformation of the population from rural to urban areas, and a gradual increase in the ratio of the inhabitants dwelling in urban areas, which is a major cause of urban problems. Increasing population growth has become a major problem for all countries of the world. The United Nations (2005) indicated that about more than three billion persons on the ground are urban residents and by 2008, about half of the world's inhabitants will live in urban areas. Egypt is part of the world also saw a rapid rise in population growth overshooting 70 million, which numbers nearly below five percent of the Egyptian regions (Aly et al., 2005) so, the Egyptian government has supported investors and businessmen to develop development projects in desert areas.

Remote sensing and geographic information systems (GIS) have a major part in urban expansion. Nowadays, to make urban planning and resolution making clearer with modern developments and progress geospatial technologies, planning and support spatial decision methods should be used (Collins et al., 2001; Malczewski, 2004 & 2006). Geographic Information Systems in combination with remote sensing, geophysical data, and different administrative registers can be utilized to define the initial risk/appropriateness through a location investigation, (Kasani, 2005). To assess the suitability of the study area for urban extension to become strong, harmless and less expensive, site investigations should be carried out also to advice on the alterations that may constipation in the earth and environmental situations of the location as a result of building and employment of the venture, (Player, 2000 and Rajesh et al., 2003).

Geotechnical characteristics of soil sheets should be recognized down for a desired deepness. From this point, we used a Geographic Information Systems technique to produce the zonation risk maps with a view to define the appropriateness of the basis soils in deserts regions (Orhan and Tosun, 2010). Geographic Information System (GIS) is a great tool because it assesses an enormous number of information for the geo-environmental valuation to do analysis of extremely big regions in a sensible period. In addition to, GIS has the capability to synthesize recent facts by integrating of different information a well-matched spatial referencing system. Nowadays, Geographic Information System (GIS) techniques has been broadly utilized to evaluate natural geo-environmental risks, groundwater susceptibility assessment and location election for rubbish removal studies, which are linked to the geo-environmental valuation for site selection of urbanization (Dai et al., 2001; Arnous, 2004; Pandey et al., 2008; Arnous and Green, 2011; Youssef et al., 2010 & 2011; Arnous et al., 2011; Arnous, 2013; Saad et al., 2017, Arnous and Omar, 2018, Saad et al., 2020 and Omar, 2021). The goal of the current work is to advance a Geographic Information System technique that assesses the geotechnical provision and considerations for harmless structure drives so; we used this technique at New Alamein city for site selection of urban extensions.

STUDY AREA CHARACTERISTICS

The Western Desert covers a surface area of about 700.000 Km^2. This region is found in the northern part of the Western Desert, on the north-western coast of Egypt (Fig.1). It is bounded from the North-East by the International Coastal Road (Alexandria-Matrouh), the North Hamam Chanal, the East Alexandria and the Petroleum Road to the West between Lat. 30º 45' and 30º 35' N and Long. 28º 46' and 29º 41' E. The study region is consisting of clastic rocks, deposition through the Tertiary and Quarterly geological ages (Selim, 1971).

Geomorphologically, the study area is divided into two main geomorphological features, Coastal plain and elevated plateau (Fig. 2) the term coastal plain refers to that part of the land which borders the sea shore (El Shamy, 1968). The coastal plain it is an area of flat land extending along the Mediterranean. This feature includes the following features [beach (Fig. 3), coastal dunes (Fig. 4), coastal ridge, coastal depressions, wave-cut platform, off Shore Island and sea cliffs]. But, the elevated plateau is located at the south of the coastal plain with an elevation of about 250 m in the south that decreases gradually to the north at the rate of 3m/km to reaching about 40 m above sea level at its extreme northern portion. The plateau consists of fissured and jointed limestone.

Climatologically, The Mediterranean Sea Coast of Egypt is characterized mainly by the windy, mild, wet winters and the relatively calm, hot summers. The climate varies seasonally along the Mediterranean area where in winter the weather is relatively cold (10^o-15^{o}C), in spring the weather is characterized by frequent, (Khamassin) dust blown winds. Where, it is mild in summer

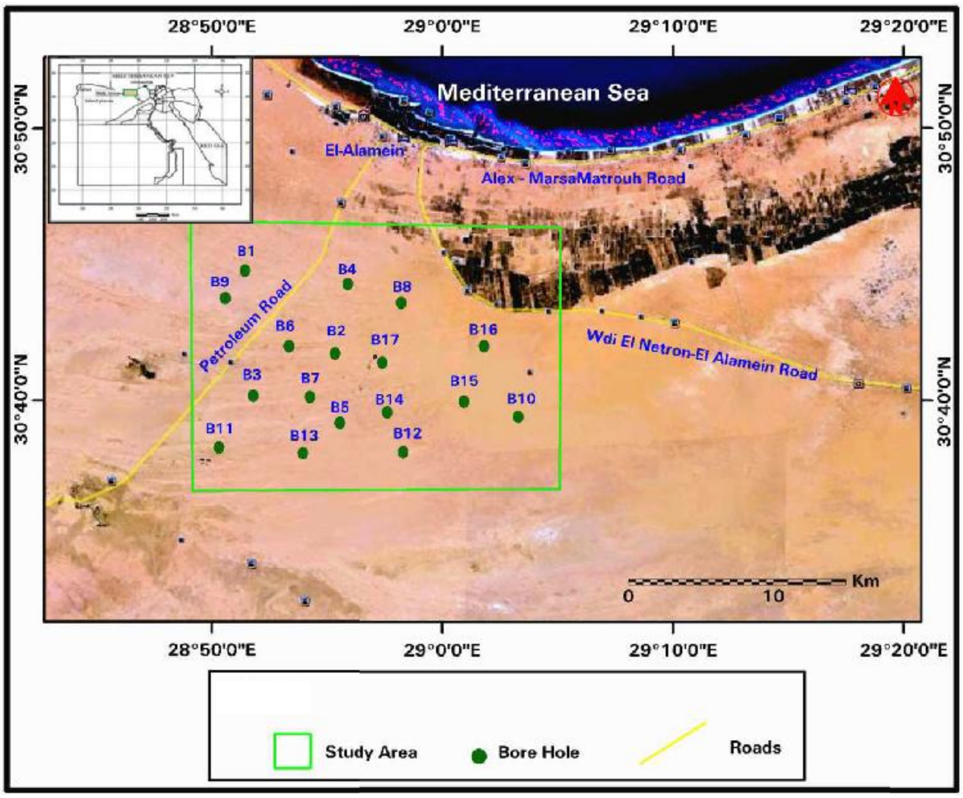

Fig. 1: Location and sample locations (B) maps of the study area

and fall. During winter, The Mediterranean Coast of Egypt is exposed to a number of stormy surges. The rate of rainfall is about 2.4 mm per minute. Wind predominately blows mainly from SW, NW directions (Moursy, 1976). Thunder storms occur in October and November about 6 times per year in the far east of the region and about 3 to 4 times in other parts of the area. Sandstorms occur mostly in winter and spring. Absolute temperature reaches to 40^{o}C. The annual variation in mean relative humidity reaches about 10%.

The stratigraphic sequence occurring in the study area spans from Early Miocene to Pleistocene (Figs. 5&6). The northeastern parts of the Qattara Depression in the study area are shown as Sand and Clay-rich units of the early Miocene period. While the southern and western borders of the study area consist of Calcareous deposits and Clay-rich sediments which belong to Middle and Late Eocene and Oligocene ages.

The area around Moghra Lake is mainly made up of Quaternary deposits. Unconsolidated aeolian Sabkha, and valleys deposits which unconformably cover the Miocene rocks are Quaternary deposits. These Quaternary deposits are unconformably underlying by the Middle Miocene deposits (Marmarica Formation) overlying the Moghra Formation of the Lower Miocene that emerge on the edge of the Qattara Depression. Owing to the presence of the research region in the northern part of Western Desert in

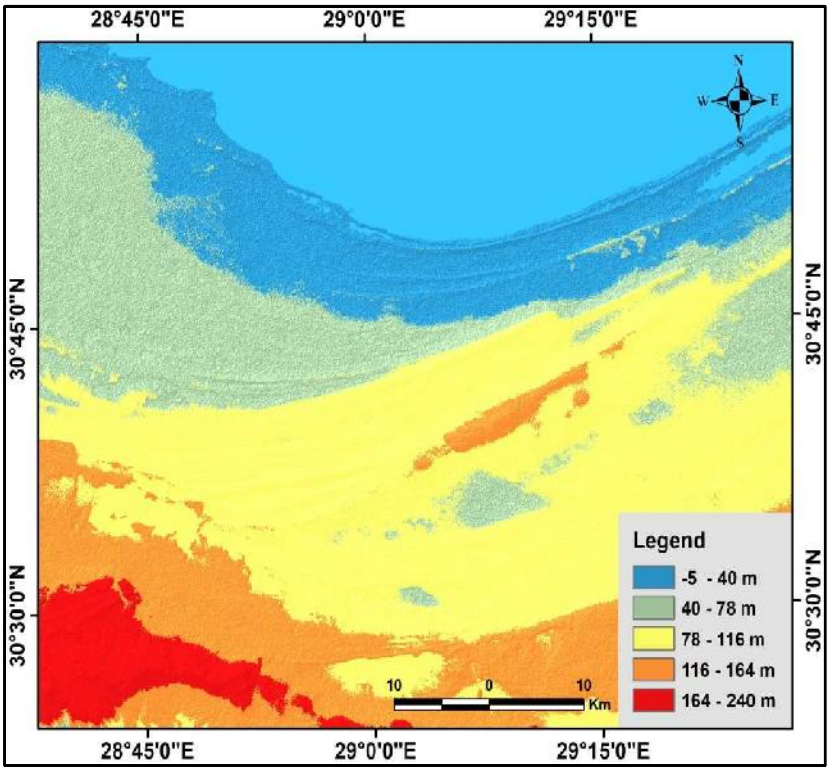

Fig. 2: Surface elevations of the ASTER Digital Elevation Model (ASTER DEM)

Fig. 3: Field photograph showing beach along Alamein area

Fig. 4: Field photograph showing coastal dunes along north western coast of Alamein area

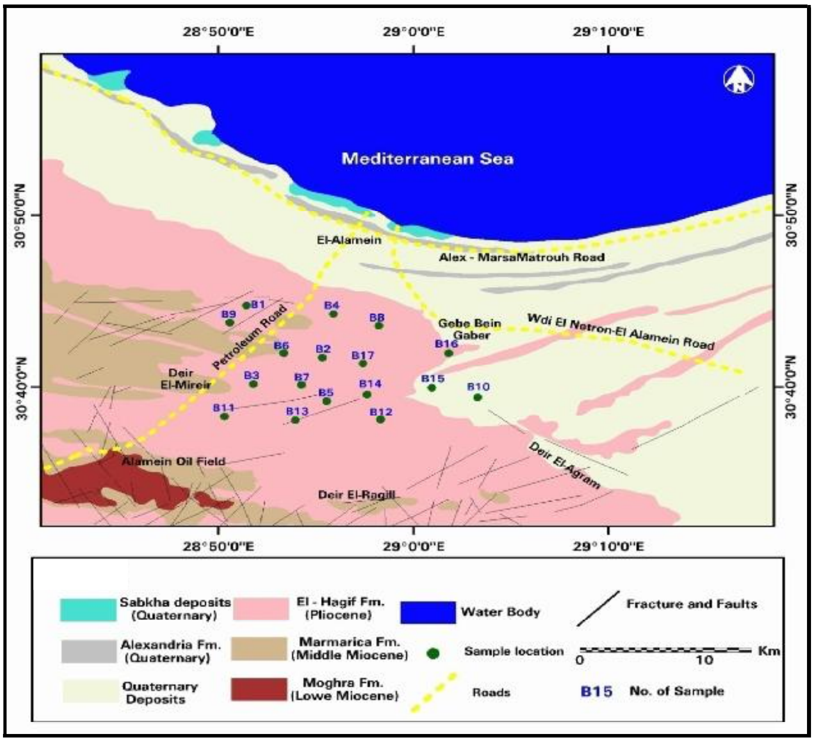

Fig. 5: Geological map of the study area (Modified after CONOCO, 1987)

Egypt and parallel to the Mediterranean Sea, the atmosphere is close to that of the Mediterranean.

Structurally, the New Alamein site is located in the northwestern Desert, at the northern terminus of the Nile Valley rift and northwest of the Gulf of Suez rift. As a result, the current area's structural environment is primarily defined by northwest centered faults that continue from these two structural realms, as well as east-west faults and folds similar to the Syrian Arc system in North Egypt (Worly Parson report, 2010).

MATERIALS AND METHODS

Large amounts of data can be integrated to produce a spatial analysis related to urban development, in order to understand collaboration between urban development patterns and processes, remote sensing, GIS and other modeling methods have to be integrated (Jianquan and Masser, 2001). The goals of the current study is applying Geographic Information System technology to collect and correlate various disciplinary data related to radioactivity and geotechnical properties that enable us to understand and assess the urban development planning. GIS is an automated tool for the storing, presentation of geographic data available and integrating the relative information to identify the most promising and prospecting sites of urban development investigate in the study area. This work has been developed by using ERDAS imagine 9.2, ENVI 4.8 and Arc GIS 10.2 and Surfer 12 software.

Also, the activity concentration of ^{232}Th, ^{238}U and ^{40}K determined using gamma spectroscopy

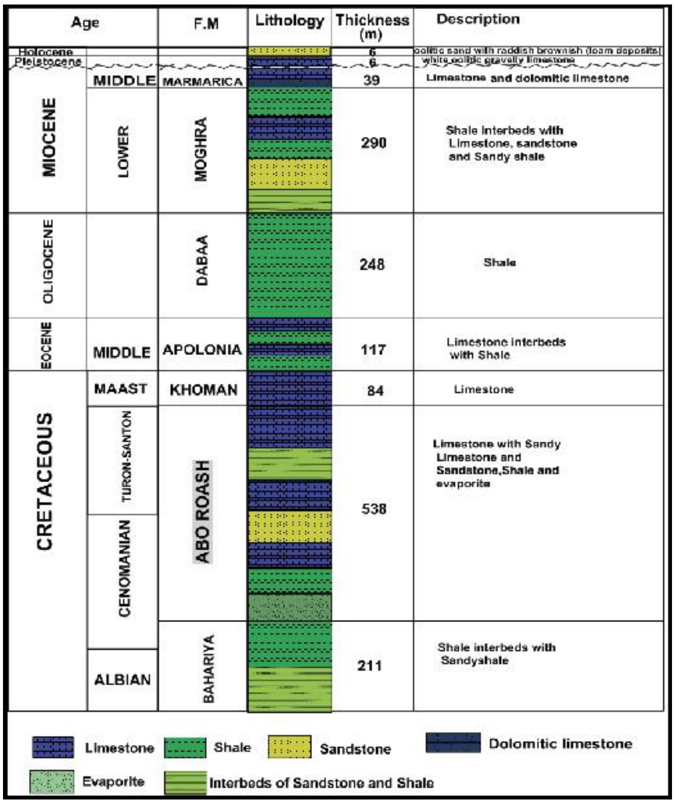

Fig. 6: Stratigraphic columnar section of the study area (After Sofratome, 1984)

technique for soil samples was studied. As well tabular information, which are containing geotechnical properties, geochemical analysis and radioactive measurements of soil. GIS is used in storage geotechnical data and radioactive measurements in addition to their geographic sites in a close database. GIS has the ability to analyze the geographic data accurately utilizing numerous reasonable situations. Also it is used for building spatial modeling of the physical and mechanical properties and radioactive measurements of the soil at New Alamein City Egypt by the integration of physical properties and mechanical properties of soil, geochemical (SO_3, Cl, TDS and pH) and radioactive data (eU, eTh, Ra and K) of soil. The modeling method was used to combine input map layers for producing integrated maps of land use. This method rate each of the input layers with respect to its ability to predict the location and priority of urban extension of the study area. The predictive map is the sum of weights from each of the input layers.

The predictive maps are categorized and counted into various factors after that combined to create the geographic model of the urban extension's prospect of the present area (Fig.7). From the integrated operation produced intersect region. These intersected regions evaluated by assuming of the score. Every producing area is identified from a score measuring its ability. Each geotechnical

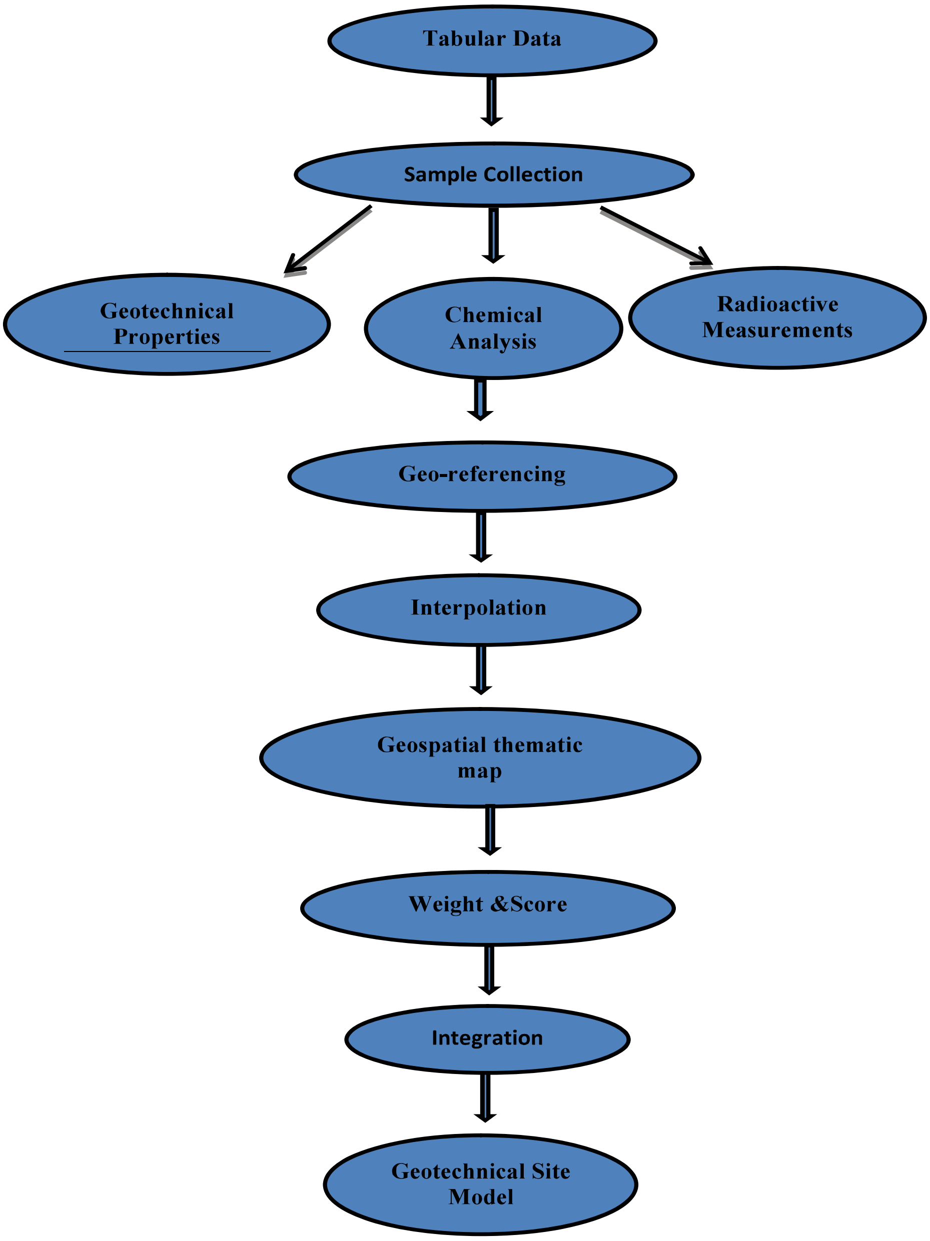

Fig. 7: Flowchart showing the methodology steps in the current study

information or any information entered into the spatial model was recorded from scale 1 to 4 in ascending arranging of urbanization evaluation. The code 4 is used with very high suitability, code 3 used high suitability. The moderately favorable parameter equals 2 and low equals 1. Table (1) illuminates the factors and classes of the mathematic weights that should be looked in the urbanization.

RESULT AND DISCUSSION

In the current study, constructed the geotechnical location investigation and urban extension model at New Alamein City depend up on collected and integrated of geotechnical soil properties, chemical analysis and radioactive measurements information of soil by using GIS technique. These informations were processed out of the several software to create the univariable and multivariable thematic maps. Univariable thematic layers are built utilizing just one variable for its values such as total dissolved solid (TDS), chloride ions (Cl^{-1}), sulfide ions (SO_3^{-2}), pH for chemical analysis of soil, liquid limit, free swell, liquidity for geotechnical properties, eU, eTh, Ra and K for radioactive measurements of soil. Multivariate thematic maps produced using more than variable to get the model such as geochemical, radioactive, geotechnical factors.

Chemical Analysis Factors

Chemical analysis of the soil factor is the chief factor affecting the constancy of basis digs in addition to the execution of the dig works. Distributions of soil chemical properties TDS, Cl^{-1}, SO_3^{-2}, pH, andec are displayed as contour maps and integrated by using GIS technique after weighting and scoring these maps to get the geochemical analysis of soil multivariate factor.

The distribution of total dissolved solids in the studied area displayed in (Fig. 8). Due to extreme evaporation and filtering of salts that crystallize in the soil, the soil becomes very high concentrations of TDS values. This process very hazard due to filtering may reason a settlement of soil beneath construction that has been established (Arnous, 2013). Present one area in the south of the current area considered as an aggressive area but in the other area is considered as non-aggressive area according to TDS distribution.

Chloride ion distribution map (Fig. 9) in the study area appears that high concentration in the northern and southern sides. So must use chloride-resistant cement types but the eastern and western sides and some parts of the south we find the ratio of chloride ions medium to very low in some places, so Ordinary Portland cement can be used.

The distribution of (SO_3^{-2}) is illustrated in (Fig. 10). The higher concentration values of sulfide in this study as a result of the existence of gypsum minerals that were filtered under pressure and concentrated of sulfide ion in groundwater. These concentrations affect the building; (Arnous, 2013). Where the concentration of sulfide ion is high in some parts of the southern region of the study area, so must use of cement resistant sulfides in these areas, and in other parts of the study area we find that the ratio of sulfide ion is average to very low so it can be used ordinary Portland cement.

The pH values in the current area are the chief factor in changing the Total Dissolved Solids (TDS), Chlorite (Cl) and sulphide (SO_4) into ions. The higher measurements of pH are a relation to soil chemical properties (TDS, Cl^{-1} and SO_3^{-2}). The distribution of pH values in the soil of the current area shown in (Fig. 11). Where we find the highest values of pH in the study area of the southern part and another region of the current area pH is average to low.

The distribution of Electric conductivity in the soil of this study (Fig. 12) shows that there are highest values of electrical conductivity widespread in some parts of the north, west and east of this study, but in other parts, we find the values of electrical conductivity ranged from average to low. So the study

Table 1: Score and categories assigned to different factors of soil geotechnical site thematic maps

Factor	Parameter	Attribute	Raw Score	Categories
Mechanical properties of soil	Consistence (%)	< 0.3	1	Poor
		0.3 - 0.5	2	Average
		0.55 - 0.75	3	Good
		> 0.75	4	Ideal
	Free swell (%)	≥ 160	1	Poor
		70 – 160	2	Average
		40 – 70	3	Good
		< 40	4	Ideal
Physical properties of soil	Liquid limit (%)	> 45	1	Poor
		40 – 45	2	Average
		30 – 40	3	Good
		< 30	4	Ideal
	Plasticity (%)	> 16	1	Poor
		14 – 16	2	Average
		8 – 14	3	Good
		< 8	4	Ideal
Chemical analysis of soil	SO_3 (ppm)	≥ 6500	1	Poor
		3500 – 6500	2	Average
		1500 – 3500	3	Good
		< 1500	4	Ideal
	Cl (ppm)	≥ 3000	1	Poor
		2100 – 3000	2	Average
		1200 – 2100	3	Good
		< 1200	4	Ideal
	TDS (ppm)	> 5800	1	Poor
		3800 – 5800	2	Average
		1800 – 3800	3	Good
		< 1800	4	Ideal
	pH	> 10	1	Poor
		9.5 – 10	2	Average
		8.5 – 9	3	Good
		≤ 8	4	Ideal
	Ec	> 3000	1	Poor
		1500 – 3000	2	Average
		1000 – 1500	3	Good
		< 1000	4	Ideal
Radioactive measurements	eU (ppm)	Under limit	4	Ideal
	eTh (ppm)	Under limit	4	Ideal
	Ra (ppm)	Under limit	4	Ideal
	K (%)	Under limit	4	Ideal

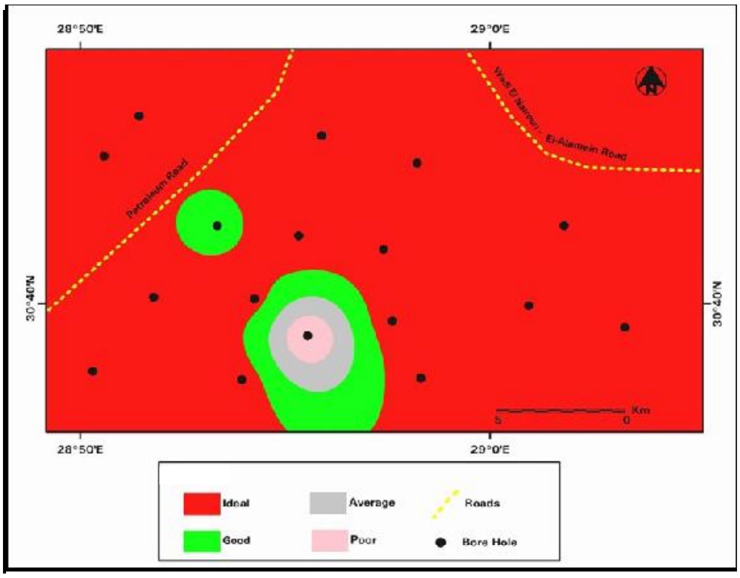

Fig. 8: TDS concentration distribution (ppm) map of the study area

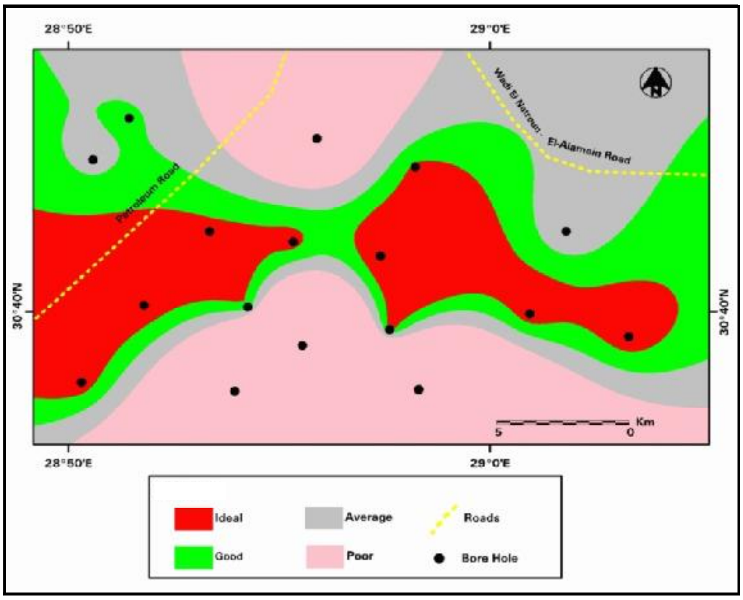

Fig. 9: Susceptibility of chloride ion distribution map (ppm) of the study area

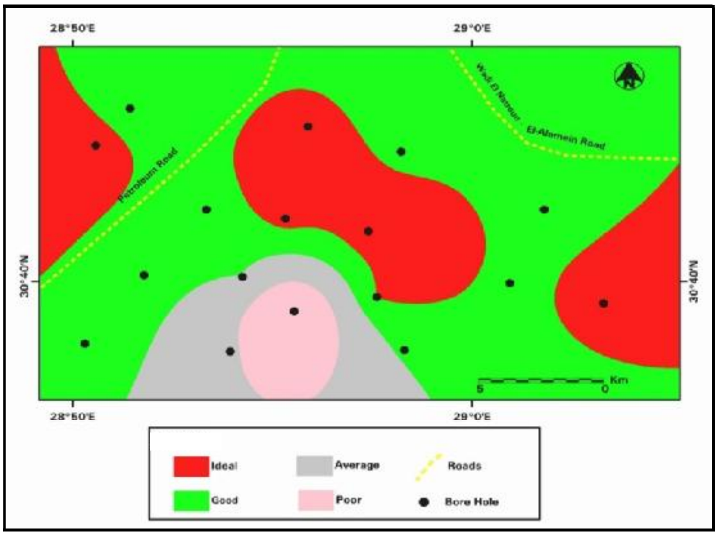

Fig. 10: Susceptibility of sulfides ion distribution map (ppm) of the study area

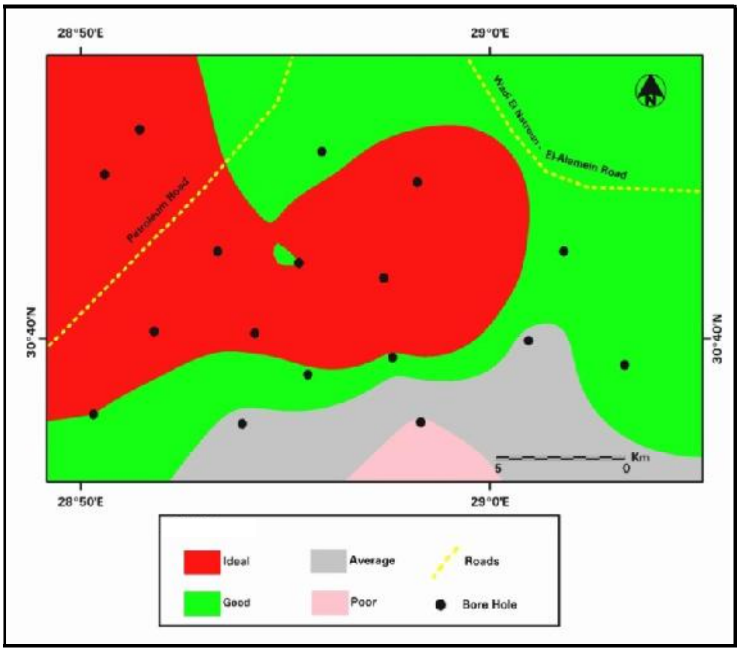

Fig. 11: The pH values distribution map of the study area

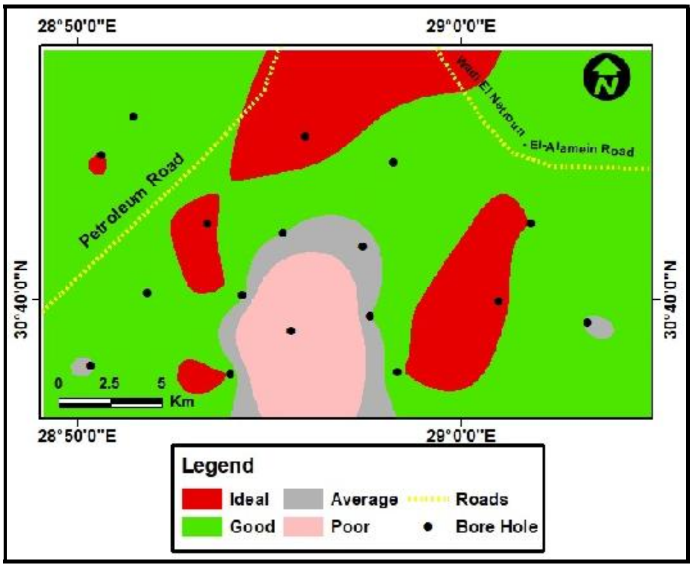

Fig. 12: Electric conductivity (EC) distribution map of the study area

area is mainly aggressive. Weighted the (SO_3^{-2}, Cl^{-1}, TDS, pH and EC) univariant thematic map then being integrated by utilizing GIS to produce the chemical factors map (Fig. 13) illustrates the hazardous area present in southern side of the study area (low suitability soil) which appear with pink color but the other areas are very good and good soil which appears with red and green colors.

Geotechnical Mapping Factors

The geotechnical mapping factor is broken into the physical and mechanical characteristics soil which performance significant factor for urban extensions. The geotechnical properties contain the following factors like liquid limit, plasticity index, and free swell coverage in the considered region to produce the hazardous maps to obtain the integration of geotechnical factor map of this study. Sodium Bentonite clay is one of the clay species, which has the ability to absorb approximately five times its own weight in the water and can swells from about 5-15 times of its dry mass. Holtz and Gibbs (1956) proposed that soils having free swell measurements like 100% can reason huge destruction to slightly loaded constructions but the soils having a frees well measurements under 50% rarely exhibition considerable change even below very slight pressure. The distribution map of the percentage of the free swell values for some samples in the study area showed in (Fig. 14). This figure shows that the ratio in some places in the northern and southern portions of this area was very high so it is difficult to directly establish them.

In the southern and central portions of the area, we find that they are very suitable places for direct establishment due to the rate of free swell value is very low. The distribution map shows the liquid limit for some samples of the study area (Fig. 15) illustrate there are some northern and western parts were high and in other parts of the study area were average to low.

The plasticity is term in which characterize the capability of the soil to subject to

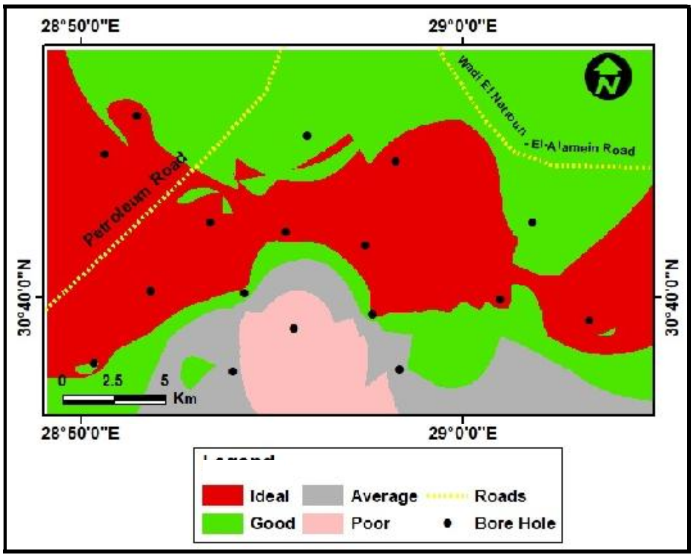

Fig. 13: Integrated chemical factor map of the study area

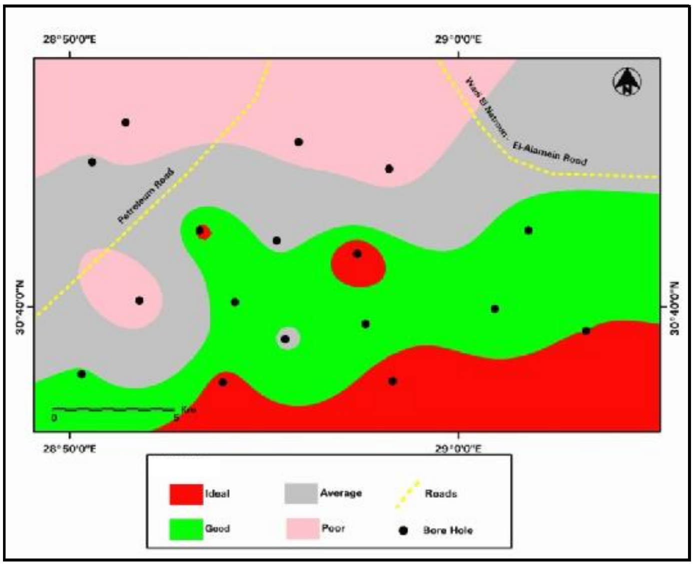

Fig. 14: Geo-spatial distribution of the free swell value (%) map of the study area

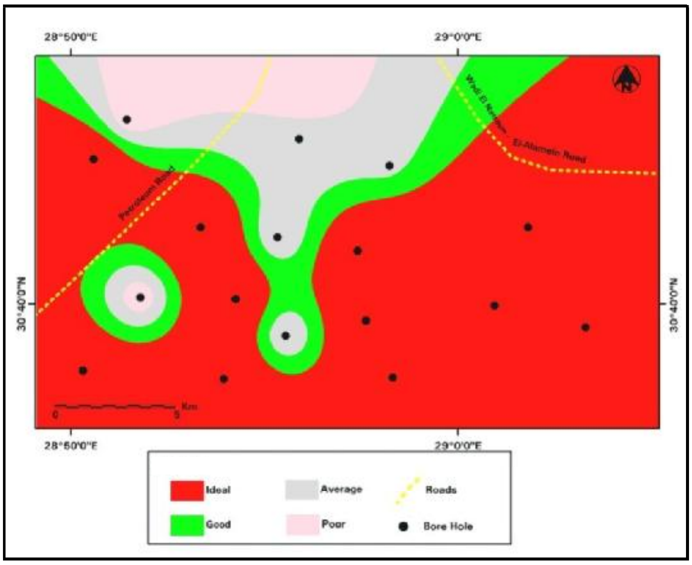

Fig. 15: Geo-spatial distribution of Liquid limit (%) map of the study area

preservation at the same volume wanting collapse, and this property is assigned to the occurrence of the clay minerals (Craig, 1982). The plasticity index distribution map (Fig. 16) shows there are some parts in northern, central and western of the study area were high and in other parts were average to low. If the plasticity index of a soil was greater it will be the construction problems related to utilizing this soil, such as a basis backing for inhabited building and sub-roads (Bowles, 1984). From integrated univariant maps of physical and mechanical properties of soil by using GIS technique to obtain the geotechnical factors map (Fig. 17) shows that the hazardous area present in northern side and small part in eastern side of the study area (low suitability soil) which appear with pink color but the other areas are ranged from very good to good suitability soil which appears with red and green colors.

Radioactive Factor

Radioactivity phenomenon is the effect of emitting radiation during the decay of the radioactive elements. This decay accompanied by the emission of alpha [$2He^4$] and beta [-1*e*0] particles and electromagnetic radiation known as gamma radiation. The alpha and beta particles have a much lower range of penetration than gamma ray (Darnely, 1982).

The activity concentration of ^{232}Th, ^{238}U, ^{40}K and ^{226}Ra which determined using gamma spectroscopy technique for soil samples were studied. The activity concentrations of the samples under investigation in Bq/Kg were determined from the photo peaks of the gamma-ray spectra corresponding to ^{40}K, ^{238}U and ^{232}Th. Radiometric studies including gamma-ray logging and quantitative uranium and thorium analyses are executed so as to contribute knowledge around the allocation of radiometric elements such as uranium and thorium in the study area. It was found that the values of the external hazard (Hex) indices were below the acceptable limits due to the uranium detection limit, while thorium ranges from 4.5 to 17 Bq/Kg at different depths from 0 to 10m (Fig.18). The ^{40}K concentration acceptable limits ranging from 1.25 to 1.9% (Fig.19). No radioactive hazard for humans

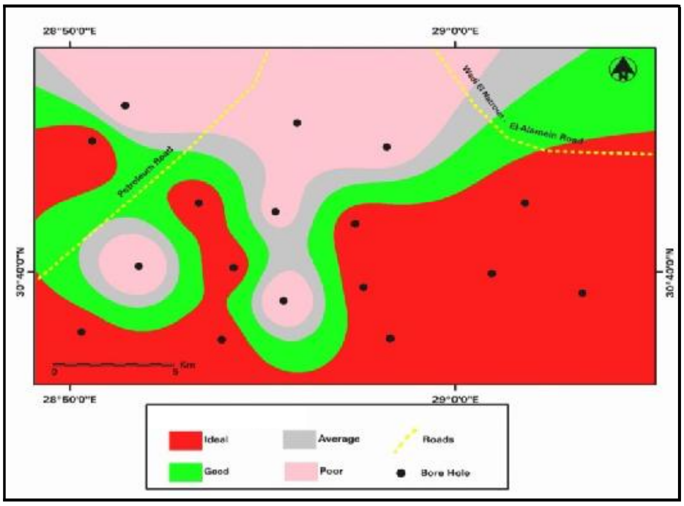

Fig. 16: Geo-spatial distribution of Plasticity Index (ppm) map of the study area

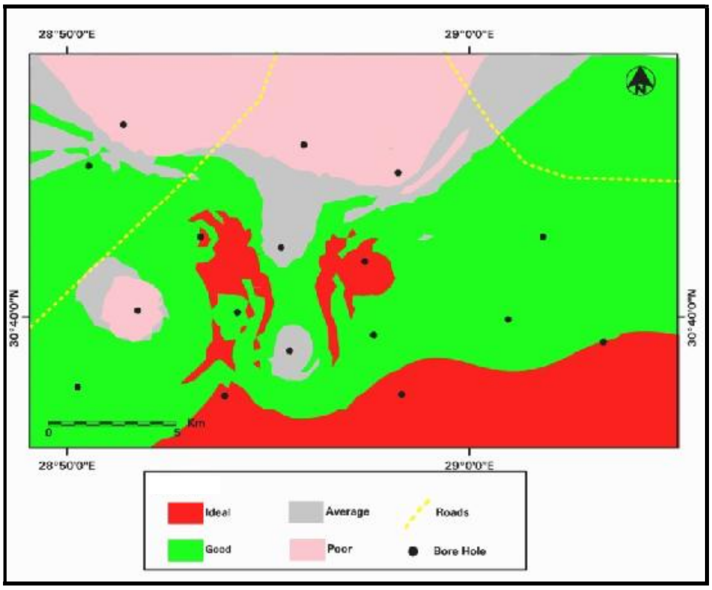

Fig. 17: Integrated geotechnical mechanical and physical (%) maps of the study area

and the study area is safe radiation, but the radium equivalent activity (Raeq) (Fig. 20) is far below the allowable limit (370 Bq/Kg) according to International Atomic Energy Agency. The values of the annual effective dose (Deff) are acceptable of the world-wide average levels which are approximately (70μ $Svyr^{-1}$).

Suitability construction map for the foundation of the New Alamein City

To prepare an appropriateness map to building in this study must be combined all previous thematic maps that dominate the construction security. These thematic maps that were utilized for the appropriateness locations analysis geotechnical soil properties, radioactive and geochemical analysis of the soil. The geographic information system technique will pick the measurements of input coverage's that are coding in the coverage layers (Table 1). Suitability construction map (Fig. 21) achieved by integrating of chemical analysis factors (Fig. 13) and geotechnical (mechanical and physical) maps (Fig. 17). This susceptibility construction map is classified into four categories. The very good and good categories have been detected towards most ofthe regions in the study area. These regions are well suitable for the foundation of New Alamein city. But the moderate suitability areas observed in the direction of the north and minor region in the south of the study region. Low suitability region for the building suggests of the basics observed towards the north and a minor region in the south of the region.

The low suitability area contains soft clay formations. This component is characterized by high compression ability and low tolerance. Furthermore, there is a linear gradient between the pressure of swelling, humidity, dry density and plasticity index is good. This may cause a lot of damage, especially if some sediment exists above this component.

CONCLUSIONS

This paper shows the capability of GIS

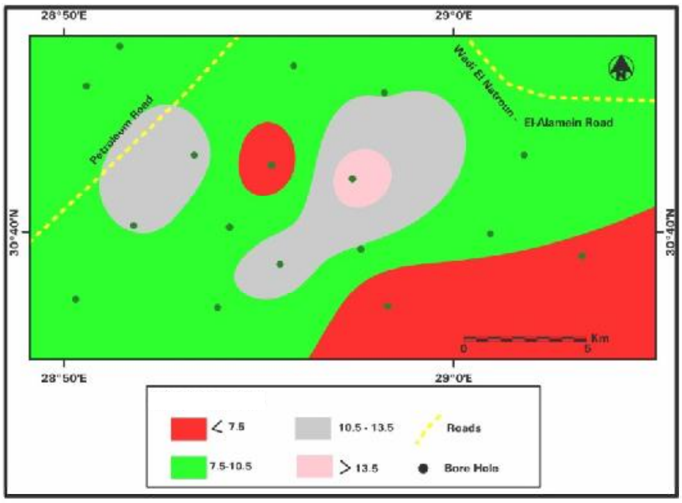

Fig. 18: Geo-spatial distribution of thorium (ppm) map of the study area

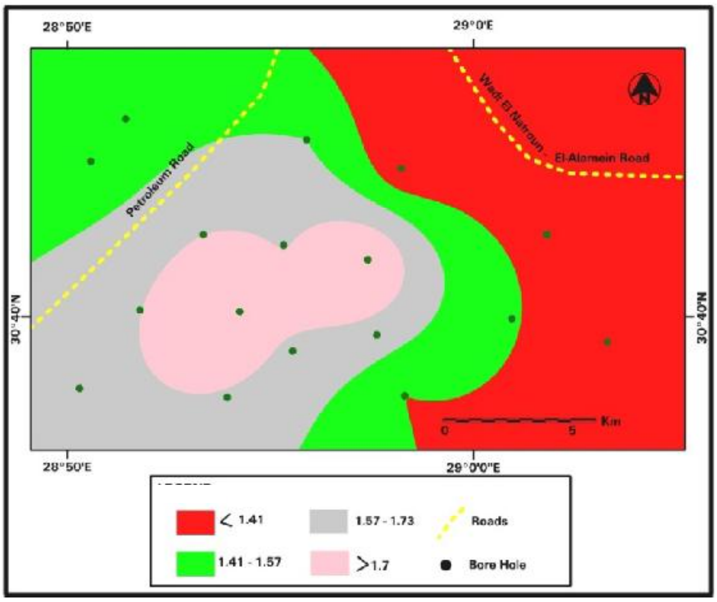

Fig. 19 : Geo-spatial distribution of K (%) map of the study area

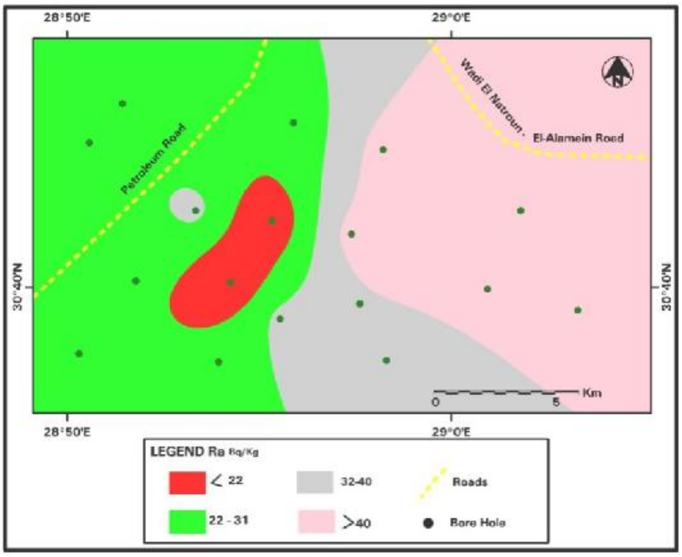

Fig. 20: Radium distribution (ppm) map of the study area

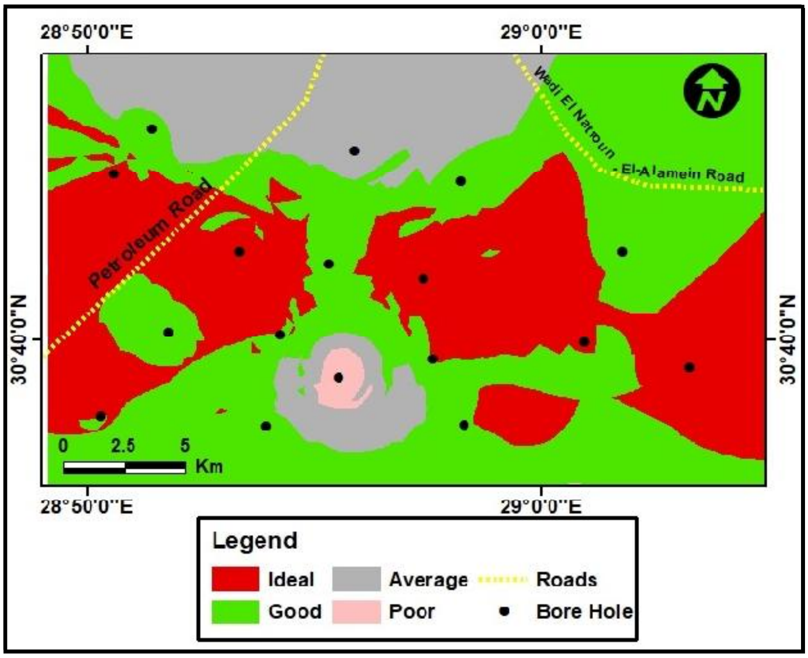

Fig. 21: Suitability construction map of the study area

techniques used for the production of the suitability construction map. A GIS-based assessment of location appropriateness could support detect the maximum ideal regions for urbanized evaluate and dodging the dangerous regions. Benefits of utilizing these materials are simple information management, fast manipulation, and analyses of information, information update and potential to produce numerous thematic layers. So, this region was classified into four categorize and the soil constructions are generally appropriate for basics which are consist on other operators such as the hydrogeochemical, geological, morphological and geophysical implementing must be prepared for the basis earlier deciding the building of the current region.

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تكامل البيانات الجيوتقنية والإشعاعية لإختيار مواقع الإمتداد العمراني بمدينة العلمين الجديدة , مصر

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تهدف هذه الدراسة إلى بناء نموذج مكانى للخصائص الجيوتقنية والقياسات الإشعاعية لإختيار افضل مواقع الإمتداد العمرانى فى منطقة الدراسة بناء على الخواص الميكانيكية، الفيزيائية، القياسات الاشعاعية والتحاليل الكيميائية للتربة وذلك باستخدام تقنيات نظم الملومات الجغرافية (GIS) ولتطوير وتحليل نموذج الموقع بالإضافة إلى المساعدة في إتخاذ قرارات سليمة والتخطيط السليم بمدينة العلمين الجديدة.

تم استخدام نظم المعلومات الجغرافية فى تقييم الدراسات الجيوتقنية والقياسات الإشعاعية بأربعة طرق هي تكامل البيانات، تصور البيانات وتحليلها، تخطيط وتلخيص انشطة الموقع وعرض البيانات. البيانات المتكاملة يمكن عرضها كخرائط التوزيعات المكانية، وبالتالى إنشاء نموذج موقع الجيوتقنية والإشعاعية لمنطقة الدراسة. يحتاج تفسير هذه البيانات إلى الموقع المكانى لدمجها فى التحليل ويتم تقدير الخواص الميكانيكية والفزيائية للتربة والتحليل الكيميائى والبيانات الاشعاعية. اخيراً تم دمج الخرائط الموزونة لإستخدام نظام المعلومات الجغرافية إستناداً إلى اغراض البناء للتوسعة الجديدة لمدينة العلمين الجديدة لتحقيق أقل التكاليف فى التصميم والبناء والعمر الطويل.

تم تقسيم منطقة الدراسة إلى أربعة مناطق حسب ملائمتها للإمتداد العمرانى وهى مناطق المثالية، مناطق جيدة، مناطق متوسطة ومناطق منخفضة. وقد لوحظ ان المناطق المثالية والجيدة متوزعة فى معظم مناطق الدراسة، بينما تلاحظ أن المناطق المتوسطة توجد فى الجانب الشمالى من منطقة الدراسة، أما المنطقة المنخفضة فهي اصغر منطقة وتوجد فى اتجاه الجانب الجنوبى من منطقة الدراسة.