Optical properties of II-VI semiconductor quantum dots

Y. Al-Douri

European Academy of Sciences (EurASc), Fondation Universitaire, Rue d'Egmont 13, 1000 Bruxelles, Belgium

yaldouri@yahoo.com

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Abstract in this research explain some equation II-VI semiconductor quantum dots and found some properties of this equation when the structural properties of undoped and Zn-doped PbI2 nanostructures with various Zn doping fractions have been investigated.

Introduction

Bulk semiconductors are an essential component of most modern microelectronic and optoelectronic devices [1,2]. However, stringent requirements for high purity and well-controlled doping place limitations on future cost reductions. Semiconductor nanocrystals have started to challenge existing paradigms in semiconductor microelectronics due to their inexpensive, straightforward synthesis and the possibility of doping by wet-chemical approaches, which open up the possibility of a new generation of cost-effective devices. For example, Mocatta *et al*. [3] have established a room-temperature chemical method for doping semiconductor nanocrystal quantum dots (QDs). The method merely involves mixing a QD suspension containing a surfactant with a solution containing the desired dopant metal salt in toluene. Doping is thought to occur by a solid-state diffusion mechanism and can be used to control the band gap and Fermi level of the host semiconductor, with an addition of Cu and Ag metal impurities yielding n- and p-type doped nanocrystals, respectively.

Owing to their small size, the doping of QDs offers a distinctive scenario; the introduction of even a single impurity atom into ~1000 atoms comprising 4 nm nanocrystal results in a doping level of $\sim 7 \times 10^{19}$ cm^{-3}, which is well within the highly doped regime for bulk semiconductors [4]. However, such elevated levels of doping cause very different effects in nanocrystals compared with bulk semiconductors. The incorporation of dopants into nanocrystals introduces impurity states that have a dramatic impact on the electronic density of states (DOS) due to quantum confinement effects, instead of merely producing degenerate or metallic behavior as would be the case for heavy doping of bulk semiconductors. Multiple impurities also promote disorder-induced effects such as the formation of Urbach tails in confined nanocrystals [5]. Interestingly, is it possible to dope semiconductor nanocrystals with metal ions that are not isovalent with a host material cation, but the ease of the method is also remarkable [6]. It has been hypothesized that this approach can be used for all QD–dopant systems in which solid-state diffusion of dopant is possible, and work is now underway to expand the technique to various semiconductors and dopants.

Methodology of research

Several types of II-VI semiconductor QDs can be synthesized, ranging from simple binary compounds to ternary alloys in which two different group-II or group-VI elements are present. As illustrated by **Figure 1**, it is convenient to categorize II-VI semiconductor QDs according to group-VI element or QDs alloy. Owing to their compositional flexibility, a diverse range of physical, chemical, and mechanical synthesis methods have been developed for the preparation II-VI semiconductor QDs, the most important of which are reviewed in the following sections.

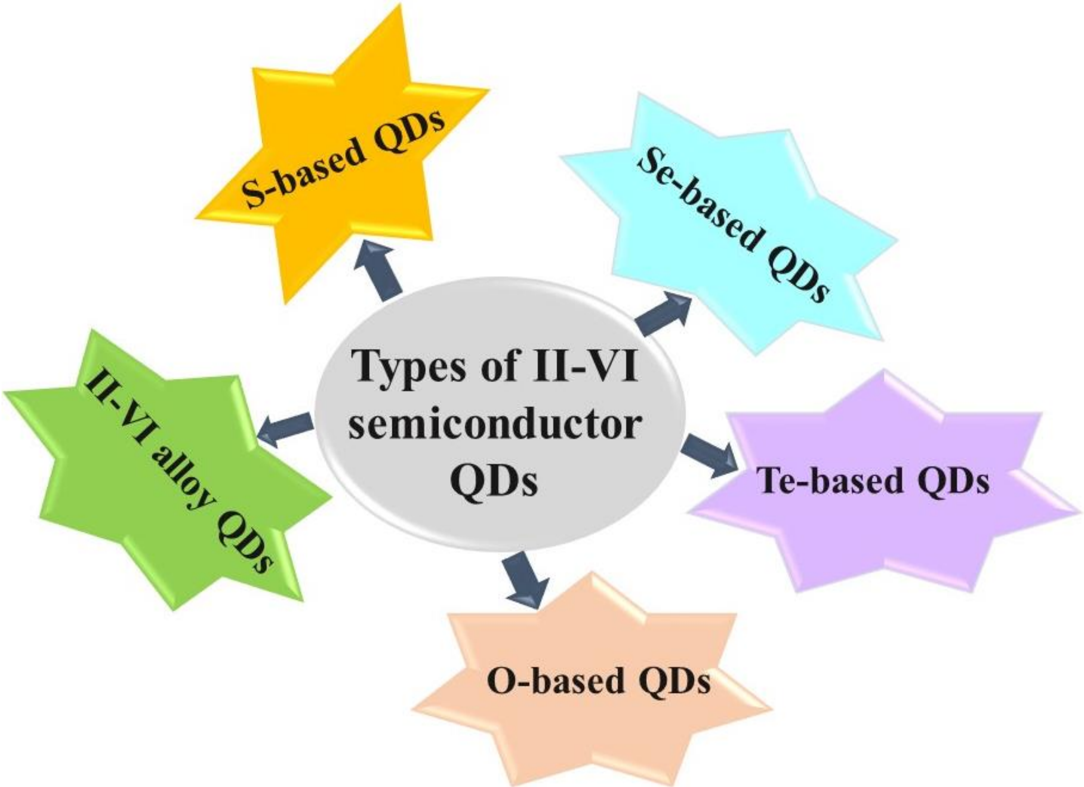
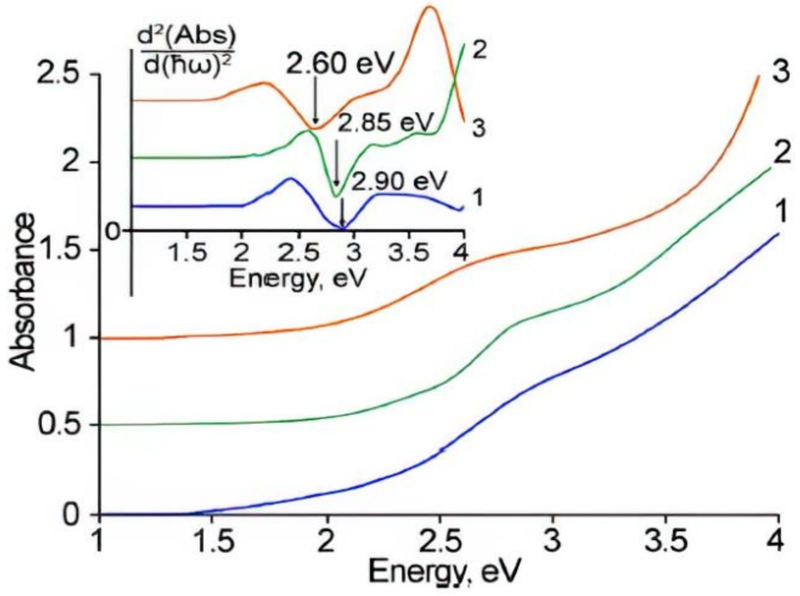


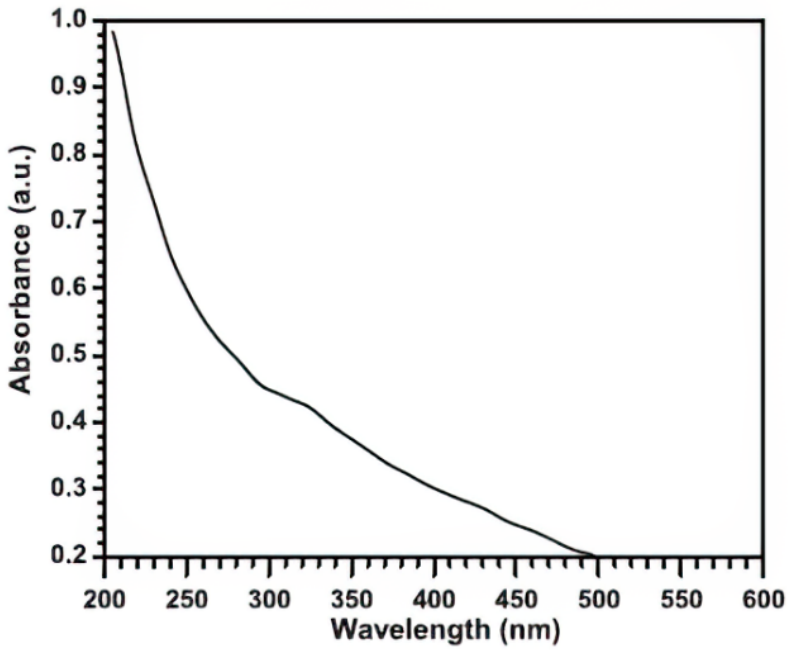
Figure 1 Types of II-VI semiconductor QDs [18].

Result of research

NiO QDs are interesting for potential optical applications due to their high transparency in the visible region and strong absorption in the UV region. Layers comprising NiO QDs with thicknesses in the range 50–200 nm exhibit an average transmittance > 80% and a band gap in the range 3.6–3.9 eV [7,8]. NiO films with thicknesses of 50 nm obtained high transmittance values, which decreased upon increasing the NiO film thickness. The absorption spectra of colloidal Ag_2S QDs display characteristic features at energies of 2.90 eV, 2.85 eV, and 2.60 eV (Figure 2). These values correspond to average QD sizes of 2.2 nm, 2.5 nm, and 3.6 nm, respectively, as obtained from TEM images [9]. The occurrence of these features is due to the first exciton transition, which is a characteristic of QD absorption. These excitonic transition energies are significantly shifted to higher energies relative to the absorption onset of bulk monoclinic Ag_2S (1.0 eV) [10-12].



(a)



(b)

Figure 2 (a) Absorbance spectra of colloidal suspensions of Ag_2S QDs with average sizes, 2.2 nm (1), 2.5 nm (2), and 3.6 nm (3) [101] and (b) Normalized absorbance spectrum of ZnSe QDs [18].

The absorption coefficient of CdTe QDs noticeably increases [13] and the peak shifts toward higher photon energy. This suggests that as the Coulomb interaction energy increases, it leads to an increase in the energy difference between the initial and final states involved in absorption. Moreover, the size of the QD obviously influences the electron density, transition matrix element, and absorption coefficient. Therefore, the intensity dependence of the nonlinear absorption coefficient near the resonant frequency is essential, and it should be considered when studying the optical properties of excitons in low-dimensional hetero-systems [14-16].

ZnS QDs have been synthesized using a chemical bath deposition technique with sodium sulfide and mercaptoethanol as the sulfur source by Shanmug *et al*. [16] The synthesized QDs were analyzed by UV-vis spectrophotometry (Figure 3), and it was observed that there is a blue shift of the absorption wavelength relative to bulk ZnS. The refractive index and associated optical dielectric constant were calculated, and correlations between the energy gap, particle size, and absorption coefficient were discussed.

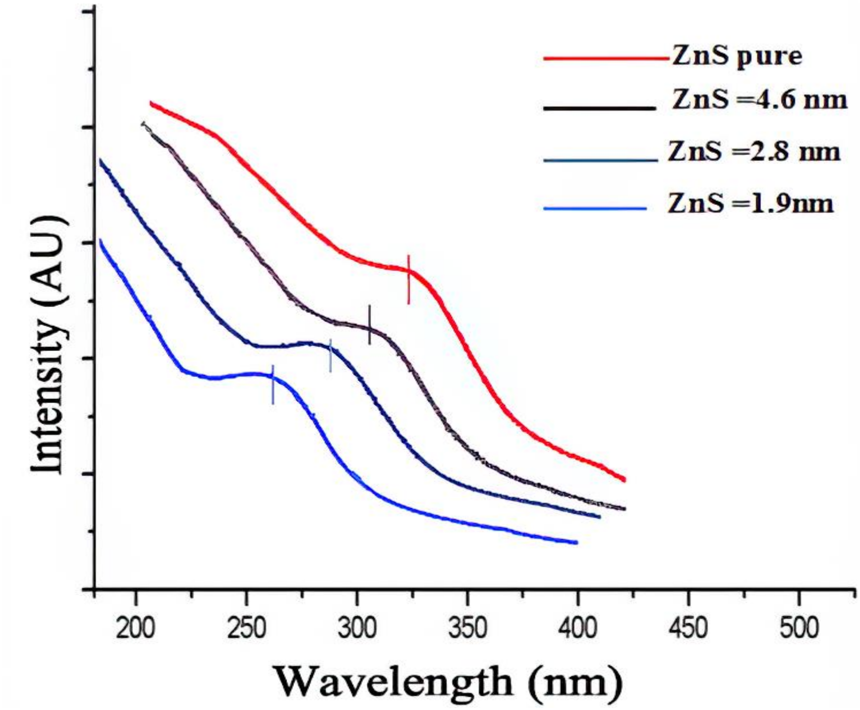


Figure 3 UV-visible absorbance spectra of various sizes of ZnS QDs [18].

The structural properties of undoped and Zn-doped PbI_2 nanostructures with various Zn doping fractions have been investigated. The undoped and Zn-doped PbI_2 nanostructures were grown by thermal evaporation using a glass substrate at room temperature, and the dislocation density and particle size of the synthesized materials were elaborated in addition to their energy band gaps. The QDs potential, refractive index, and dielectric constant were calculated [17], which are relevant to QDs and solar cells application. The obtained results were in good agreement with both experimental and theoretical data.

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Plant Distribution with Geological Features in Teeb as a Potential Geopark Area, Misan Governorate, Iraq

Moutaz A. Al-Dabbas[1,a] *, Khansaa R. Al-Joboury[2,b], and Hind M. Abdulsattar[3,c]

[1]Department of Geology, College of Science, Baghdad University, Baghdad, Iraq.
[2]Iraq Natural History Research Center and Museum, University of Baghdad, Iraq.
[3]Department of Computer Science, College of Education for Pure Sciences(Ibn Al-Haitham), University of Baghdad, Baghdad, Iraq.
[a]profaldabbas@yahoo.com,[b]dr.khansaa@nhm.uobaghdad.edu.iq,
[c]hind.moutaz@ihcoedu.uobaghdad.edu.iq

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Abstract. There is an inherent connection between living and non-living nature. Variability in geology, soils, topography, geomorphology, and hydrology is known as geodiversity and is considered the basis and stage of biodiversity. Field surveys in the Teeb area, Misan Governorate, Iraq, showed that it comprises shallow depressions, fill deposits of clay, sand, and silt sediments less than one meter thick, and flat floodplain sediments containing sand and clay in varying percentages. Dunes and sand sheets are also dispersed throughout the Teeb area. With an average of 49.6% silt, 34.4% clay, and 15.9% sand, the texture analyses of the sediment samples from the nine locations show that silt makes up a sizable portion of the study site's sediment. The diversity of plants in the Al-Teeb area varies according to soil types, sediments, and water availability. At the study's family level, the plant samples are diagnosed. 39 monocotyledonous and 114 dicotyledonous plant species from the Amaryllidaceae, Cyperaceae, Liliaceae, and Poaceae families were found. However, the Asteraceae family has the most incredible species diversity because of its resilience to harsh environmental factors like salt and water scarcity. Although there are fewer species from the other families, they are observed. **The** novelty of this research is that it indicates the suitable geological and biological characteristics of the Teeb area as a potential Geopark area for geotourism and entertainment potential. This potential is an opportunity for local development. Different types of rural recreational activities can be done at geological sites.

Introduction

Recent scientific findings show that geodiversity positively affects biodiversity in various settings, geographical locations, and spatial scales. Therefore, tying these two ideas together and embracing interdisciplinary collaboration holds great promise for improving the comprehension of natural diversity and incorporating geodiversity into conservation evaluations at various scales.
Geohritage depends mainly on geodiversity factors, which include geologic, geomorphologic, soil features, and water resources. Diverse landforms provide many habitats and ecosystems that contribute to biodiversity enrichment.
Tourism is an essential industry that contributes to stimulating socio-economic development. Due to people's desire to travel to geological and natural areas, tourism has received significant attention from officials and specialists. Diverse ecosystems have contributed to the enrichment of

biodiversity.
A Geopark includes a vast area with distinct boundaries, specific geological features, and social and cultural heritage. The eastern part of Misan Governorate is assessed as a potential geopark according to scientific, educational, functional, and geo-tourist criteria.
According to this approach, the Teeb area location is selected [1]. Geodiversity provides diverse ecosystems such as deserts (sand dunes), mud flats, salt flats (sabkha), and aqueous ecosystems. Involved ecosystems help a wide range of plants to grow and animal species to live and breed. Al-Teeb and adjacent areas can be used for geotourism, education, scientific research, and other sustainable developments.
The selected site is characterized by distinctive surface and subsurface geological structures, which can be a geological tourism area and geopark.
The Teeb area in Misan Governorate was chosen to investigate the relationship between Plant diversity distribution and Geological features.
Teeb river course, floodplains with wetlands, shallow depressions, fill deposits, sand dunes, and sand sheets are geological features dominated by herbaceous rather than woody plant species. The Teeb area includes aquatic and terrestrial ecosystems dominated by grasses, bushes, and reeds. Thus, that form of vegetation differentiates each distinctive part of Teeb. Some researchers studied the Teeb area, such as Al-Moozani, 2008 [2] and Al-Abadi, 2011[3], who studied the main aspects of geomorphological and hydrological conditions of the eastern and northeastern parts of the Misan governorate.
The rise in temperature significantly highlighted the phenomenon of desertification and drought, which had a clear impact on the areas of arable land and, thus, on the agricultural sector in general. Therefore, it is essential to investigate Plant diversity distribution with Geological features in Teeb as a potential Geopark area.
Like other countries in the Middle East, Iraq is famous for its great diversity of wild plants, which depends on geographical diversity and climate conditions [3]. The Foothills Region is one of Iraq's most essential and diverse physiographic regions. The southeastern part of Iraq that runs along the Iranian border is the Teeb area, Misan governorate at the Hamrin Mountain has good geopark potential [4, 5, and 6]. It is characterized by geodiversity and biodiversity (such as diversity in geology, topography, soil, and plant diversity) [5 and 6]. The Teeb area is distinguished by the soils characterized by the diversity of sands of soft quality to compact gravel sands or sometimes clay. USDA-SCS, 1975, [7] concluded that the textural classes are classified as loam, whereas soil with 40% sand, 40% silt, and 20% clay. The Teeb area soil description reveals they are of sand and loamy sand, silt, and silty clay loam. Vegetation varies according to seasonal soil moisture, which in turn depends on time, amount, and rain season [8,9 and 10].
In the spring, the Teeb area is dominated by many interesting annual and perennial herbs, while in Summer and Autumn, nearly all the annuals die [11]. In general, the area in Autumn is dominated by shrubs or bushes, rarely trees of closed communities, sometimes of [11 and 12].
This study aims to investigate the Teeb area in terms of geological, soil texture, and plant diversity, as well as the plant density and distribution in each part of the Teeb area's geographical location.

Location and Geological Setting

The study area is located in the northeastern of Misan governorate, south of Iraq, between the latitude 32° 15' 00" - 32° 45' 00" N and longitudes 47° 5' 00" - 47° 30' 00", (Fig.**1**). It encompasses an area of 1856 km^2. The topography elevation ranges from 7 – 230 m, and the land surface is relatively flat in the central part of the area, bounded by Hemrin Mountain in the northeastern and Band Mountain in the northern parts. The area slopes from northeast to southwest. It is crossed by two rivers, namely, Teeb and Dewereg, originating in Iran territory. The bigger one is Teeb, which enters the Iraqi territory at the Teeb town north of the study area and runs from north to south until it ends in marshes outside the study area. The Dewereg enters the Iraqi territory at the Fauqi area and runs from east to northeast until it finishes in marshes. The total lengths of the Teeb and Dewereg rivers within the study area are 63 and 35 km, respectively. Most of the catchment areas of the rivers lie inside Iran. They enter Iraq at an elevation of about 100 m.a.s.l. Generally, the river's water is considered to have a saline quality. The annual inflow of the Dewereg River is estimated to be about 0.36 to 0.8 billion m^3, while the Teeb River's annual inflow is about 0.45 billion m^3 [13].

The surface drainage has an intermittent flow regime because of the prolonged drought period. Hence, groundwater constituents are the leading water resource in the study area. The region is famous for its brick industry and gravel and sand quarries. Few hands dug wells, spreading unevenly throughout the area. Residents use them for watering livestock and limited agricultural activities, in particular, the cultivation of watermelons. Also, a few deep artesian wells (< 5 wells) with potable water are drilled in the Al-Zubidat area northeast of the study area close to the Hemrin Mountain. Geological Formations outcropped in the northeastern part are Bai Hassan and Al-Mukdadiya, which represent Tertiary deposits. At the same time, deposits of Quaternary cover the rest of the area. The climate of the Teeb area is sub-arid to arid. The study area is within the unstable shelf [14, 15].

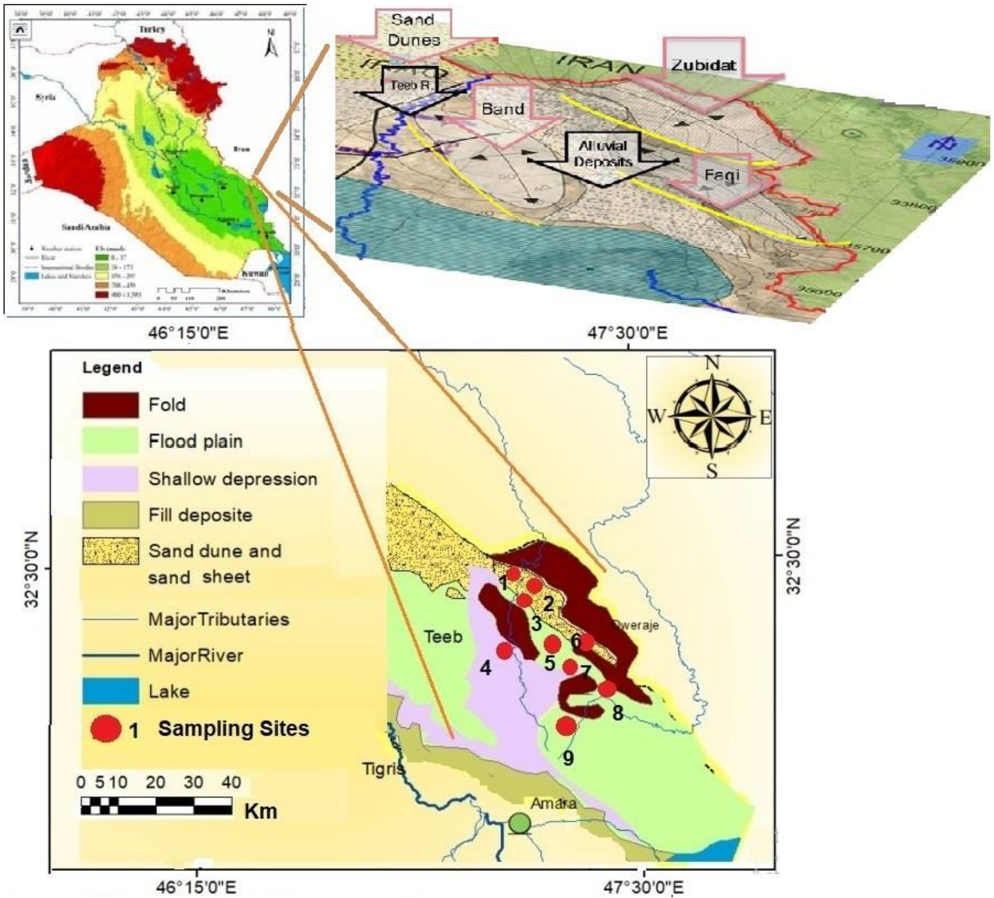


Figure 1 The Sampling sites' location and the study area's Geomorphological map.

Quaternary deposits

Most of the study area is covered with different types of Quaternary deposits, mainly sand and alluvium deposits of recent Pleistocene age. The Quaternary sediments are unconsolidated and usually finer-grained than the underlying Mukdadiya and Bai Hassan Formations. Alluvial fans, flood plains, depression fills, and aeolian deposits are the study area's major units of Quaternary deposits. Alluvial fan deposits comprise gravel, sand, and silty sand. These sediments form a strip along the foothill zone. The maximum thickness of the alluvial deposits may reach 15 m. Poorly sorted coarse deposits of cobbles and sometimes boulders occur in apical parts, passing into finer-grained, better-sorted layered fluvial sediments. The outer rims of the fans consist of sand and silt. Gypcretes also developed on the surfaces of some fans. Floodplain sediments comprise layers of silt clay and clay typically 10-20 cm but sometimes up to 1m thick. Depression fill deposits are generally radish-brown fine sand, silt, and clayey silt. Three types of aeolian sediment are currently found in the area: dust fill-out, mobile and without precise forms, and sand dunes. The dust is silty, radish-brown, and calcareous [14]. The Al-Teeb area is characterized by natural diversity and is considered a tourist area with a distinctive geographical environment. It is considered of great economic importance at the local and national levels due to the presence of large oil fields, Gravel and sand quarries, water springs, and groundwater, in addition to the presence of sedimentary and geological structures, such as folds and faults, large alluvial fans, sand dunes, and river valleys. Cliffs of high rock and low hills distinguish its northern parts. It contains many archaeological sites and religious shrines, giving it cultural, scientific, economic, and geo-tourism importance. It covers an area equivalent to 13,415 km². It is about 46 km from the city center of Amara (Fig.1). Therefore, the Al-Teeb area is assessed as a potential geopark area.

This research aims to investigate the Teeb area in terms of geological, soil texture, and plant diversity, as well as the plant's density and distribution.

Materials and Methods

A. Many field trips were carried out during the year 2022 to survey the geology and the surface sediment of the Teeb area and to get a general idea of the geology and geomorphology of the region. Relatively detailed information is determined for the local Quaternary sites' differences, such as floodplains, shallow depressions, fill deposits, sand dunes, and sand sheet sediments. Many samples (more than 3) are collected from each site to determine the average textural parameters of recent sediment and soil for the Teeb area. Accordingly, the soil characteristics and surrounding environmental conditions are indicated to determine the plant diversity in those sites characterized by biodiversity in all aspects to study the plant diversity. Thirty-six samples were collected through field trips from the Teeb area distributed in nine sites at about 15 cm below the surface after removing the topsoil cover. The distance between each sample and another is about two kilometers at all sites. The nine sites are chosen for the Teeb area according to the geographic location (site 1, site 2, site 3, site 4, site 5, site 6, site 7, site 8, site 9) (Fig.1).

B. Grain size analysis of the sediment samples is determined according to Folk 1974[16] procedure in the laboratories of the Department of Geology, College of Science, University of Baghdad. The sieve analysis is the distribution of particle sizes expressed as a percent of the total dry weight for 36 samples. 100 gm per sample was sieved in a Ritsch Shaker for 15 minutes using a set of sieves at (1Phi) intervals from -1Phi (2mm) to 4Phi (0.0625 mm). The pan in the bottom of the sieves will accumulate the mud size (silt and clay). Nine samples of mud size were chosen, one from each sampling site, to determine their grain size using hydrometer analysis following Folk's 1974[16] method. In this procedure, 15 grams from each sample were taken, the sand fraction was separated by wet sieving, and the grain distribution for the mud fraction was carried out by the pipette method.

C. The Plant samples were diagnosed at the family level in the Plant and Environment Laboratory at the Iraq Natural History Research Center and Museum, University of Baghdad [17- 21].

Results and Discussion

A. The field surveys revealed that the following quaternary sediments are found in the Teeb area such characteristic types as:

1. Flood Plain sediments (Holocene): The Flood plain is the flat area occurring on both sides of the Teeb and Dewerage streams, which is flooded and filled with large amounts of deposits. The thickness of these sediments may reach several meters. The thickness decreases considerably to get a few meters near the Iraqi border. Sediments mainly consist of sand and clay with different combinations. During periodic rain in the winter months, water from the Iranian side of the border drains onto the flat area, resulting in occasional floods. The evaporation of this water results in a

large area of salt accumulation (i.e., Sabkha). The sediments that fill Sabkhas are sand, silt, and clay in varying combinations.

2. Shallow depression and fill deposits: Depression fill sediments are accumulated in shallow depressions of different areal extents. These shallow and small depressions are almost less than one meter thick and are filled with rainwater. The composition of the fill sediments is clay, sand, and silt.

3. Aeolian sediments "Sand sheet and Sand Dunes": The aeolian sediments are spread over the upper northwest part of the Teeb area and a small area to the east. It could be found in the simplest form of aeolian sediments like nebkhas and drifting sand sheets. The thicknesses of aeolian sediments range from one meter for the sand sheets to about 5 m, depending on the form of accumulation—well-sorted windblown sand grains in wave-like mounds or ridges. A series of sand dunes that vary in size and degree of stability occur parallel to Hemrin Mountain.

B. Particle size distribution is widely used in sedimentology, geomorphology, and soil science. The texture analyses of the nine sites' sediment samples reflect that the silt is a significant part of the sediment of the study area, where the Silt average is 49.6%, ranging between 34% and 64.6%. Clay's relative distribution average is 34.4%, ranges between 25.7% to 49%, and Sand average is 15.9%, ranging between 9.4% to 26%, Table 1. The USDA 1986 [22], sediment texture triangle is applied so that any combination of particle sizes distribution classification could be included within a textural class, Fig. 2.

C.

Table 1. The average percentages of sand, silt, and clay distribution analysis of the Teeb area.

site No.	Sand %	Silt %	Clay %	Type of texture according to USDA, 1986 [22].
site1	25	47	28	sM (Sandy mud)
site.2	26	40	34	sM (Sandy mud)
site.3	9.7	64.6	25.7	sM (Sandy mud)
site.4	11.3	59.2	29.5	siS (Silty sand)
site.5	21	48	31	siS (Silty sand)
site.6	14	52	34	sSi (Sandy silt)
site.7	9.4	51.3	39.3	sSi (Sandy silt)
site.8	16	35	49	siS (Silty sand)
site.9	11	49.5	39.5	siS (Silty sand)
Average	15.9	49.6	34.4	sSi (Sandy silt)

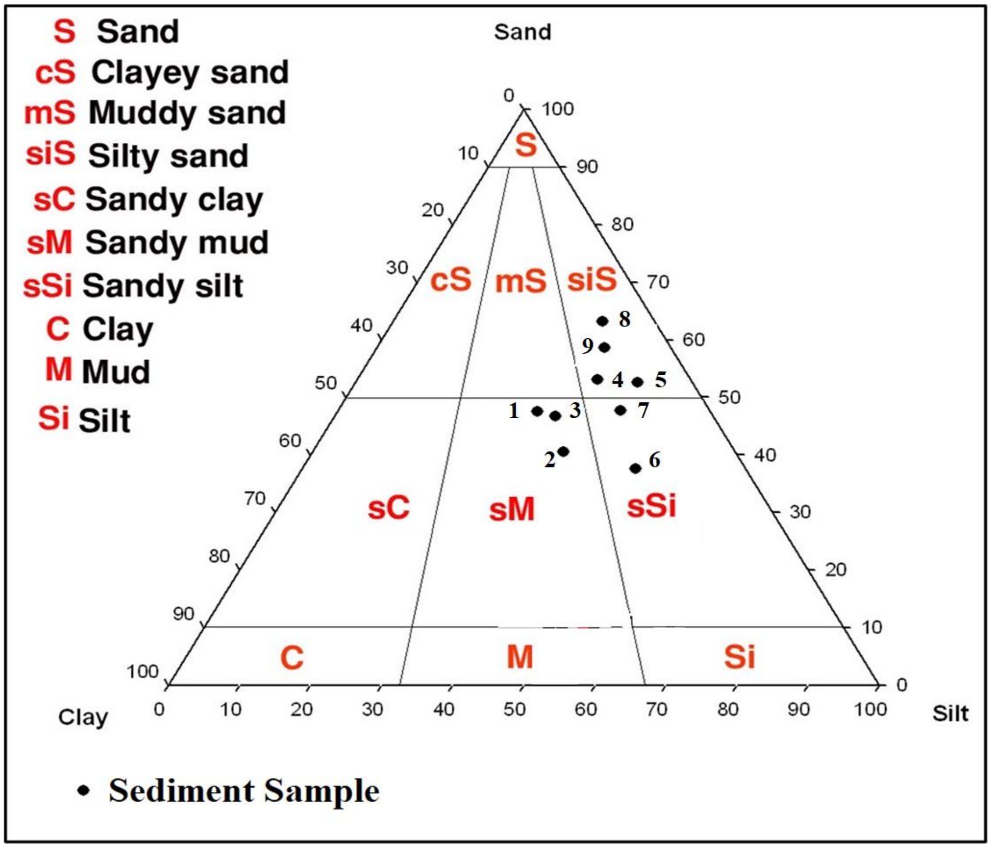
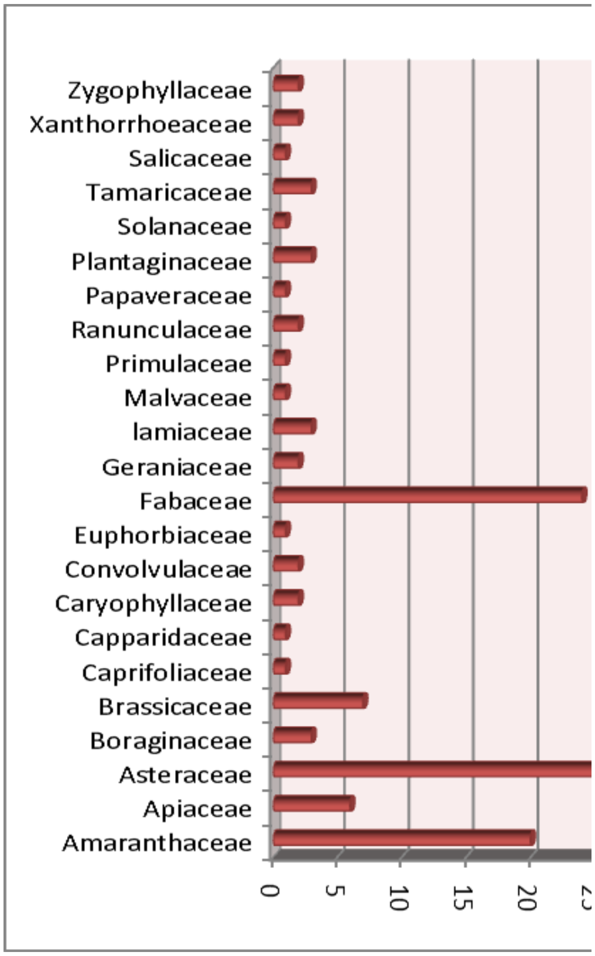
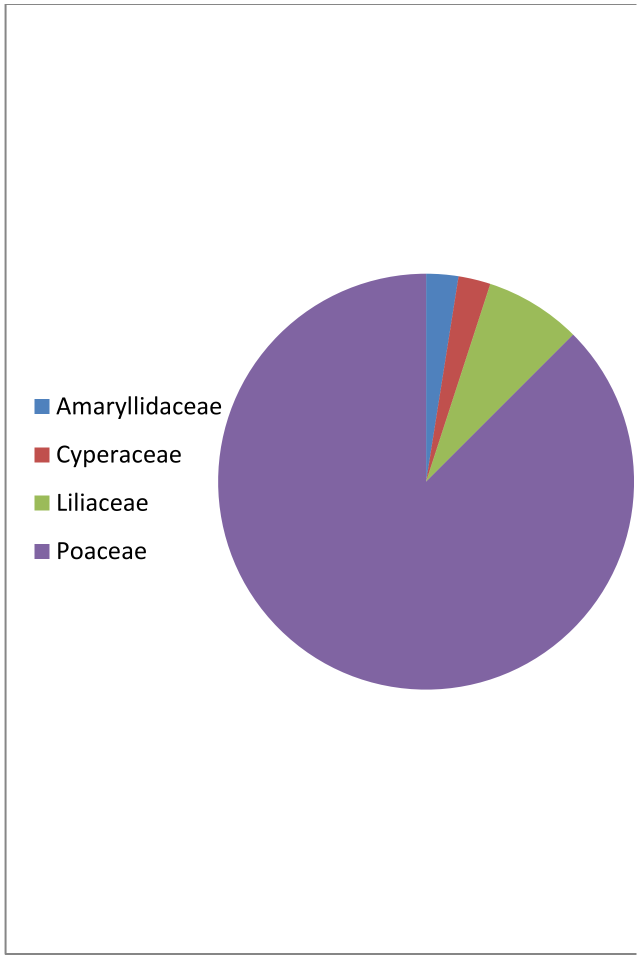


Figure 2 Classification of the sediment of the study area (after USDA 1986 [22]).

D. The Al-Teeb area is distinguished by the variation in plant diversity, as they were very diverse in some sites, while others were less diverse depending on water availability, sediments, and soil types. It is also noted, after diagnosing all the plants, that they are monocotyledonous and dicotyledonous plants. The Plant samples are diagnosed at the family level of the study. The results recorded 114 plant species of dicotyledonous which belong to the plant families: Amaranthaceae, Asteraceae, Fabaceae, Apiaceae, Brassicaceae, Zygophyllaceae, Caryophyllaceae, Euphorbiaceae, Solanaceae, Primulaceae, Boraginaceae, Plantaginaceae, Salicaceae, Lamiaceae, Convolvulaceae, Ranunculaceae, Capparidaceae, Geraniaceae, Malvaceae, Papaveraceae, Xanthorrhoeaceae, Tamaricaceae, Caprifoliaceae, and 39 of monocotyledonous plants belong to the families: Amaryllidaceae, Cyperaceae, Liliaceae and Poaceae, Random areas from which plants were collected are (Fig. 3).





(a) (b)

Figure 3 The intensity of distribution and spreading of dicotyledonous and monocotyledonous families in the Al-Teeb area, a: number of occurrences of the dicotyledonous plant families, b: Pie diagram represents the percentages of the monocotyledonous plant families.

The distribution of plant families and the description of each sampling site are as follows:

1. Al-Teeb River banks and floodplains area is characterized as one of the most diverse study areas represented by the sites 1, 2, and 3. It is of the fertility soil consisting of mud, silt, and sand, as well as it is characterized by the water availability from the Al-Teeb River. The average grain size of their sediments is Sandy mud (sM) (Figs. 1 and 2; Tables 1 and 2). It is characterized by the spread of dicotyledonous plants, especially the Amaranthaceae, Asteraceae, and Fabaceae families, which are the common species in that region as well as the Tamaricaceae, Solanaceae, Brassicaceae, Fabaceae, Caryophyllaceae, Euphorbiaceae, Boraginaceae, Salicaceae, and Xanthorrhoeaceae. The monocotyledonous plants are distributed in this area as well, which include: Amaryllidaceae, Cyperaceae, Liliaceae, and Poaceae. It was noted from the collected and diagnosed plants that the family Poaceae is the most numerous and widespread in this area.

2. Shallow depression and fill deposits: These areas depend only on rainwater and represent alluvial fan deposits, depression fill, and aeolian deposits of Silty sand sediment classification (siS) such as in sites 4 and 5 (Figs. 1 and 2; Tables 1 and 2). These depend on the type of sediments and local soil, whether they are suitable or not for plantation. Some locations are characterized by a simple diversity in the number of plants such as site number 4, while site number 5 soil is relatively suitable for the needs of the plants due to the availability of all appropriate environmental conditions. The following Dicotyledonous plant families are recognized Amaranthaceae, Fabaceae, Zygophyllaceae, Ranunculaceae, Geraniaceae, Tamaricaceae, Apiaceae, Brassicaceae, Lamiaceae, Caryophyllaceae, Papaveraceae, Plantaginaceae, Convolvulaceae, and Malvaceae.

3. Aeolian sediments (Sand sheets and Sand Dunes): This area represents strips along the mountainous area and the foothill zone. The sediment in this area is affected by the dune and sand sheet zone and is classified as Silty sand (siS) (Figs. 1 and 2; Tables 1 and 2). It is characterized by simple plant diversity, and also characterized by the diversity of many distinctive plants in the form of clusters or individually such as in sites 6 and 7. However, it was noted that the Poaceae family spread a lot, as well as Apiaceae, Brassicaceae, Lamiaceae, Convolvulaceae, Geraniaceae, Primulaceae, Capparidaceae, Boraginaceae, Amaranthaceae, Fabaceae, Ranunculaceae, and Plantaginaceae.

4. The Sabkha areas with salt accumulation: This region was characterized by a lack of plants and characterized by simple plant diversity in the form of clusters at far distances from each other. The sediments of the region are Floodplain sediments, with Sabkha as areas of salt accumulation and classified as Silty sand (siS*)*. It is characterized by simple plant diversity, such as Lamiaceae, Tamaricaceae, Asteraceae, Zygophyllaceae, and Amaranthaceae as represented by sites 6 and 7. There are two species observed in large and clear, and some of them were in the flowering period and others in the fruiting period: Caroxylon jordanicola (Eig) Akhani & Roalson and Halothamnus iraqensis Botsch belonging to Amaranthaceae family. The prevalence of these two species was distinctive in that region (Fig.4).

Table 2. Distribution of plant families in the study areas.

Sampling Site	**Dicotyledonous plants families**	**Monocotyledonous plants families**	**Sites' Geological description**
1	Tamaricaceae, Solanaceae, Apiaceae, Brassicaceae, Xanthorrhoeaceae, Fabaceae, Asteraceae	Amaryllidaceae, Cyperaceae, Liliaceae, and Poaceae	Al-Teeb river floodplains, sM (Sandy mud)
2	Amaranthaceae, Fabaceae, Apiaceae , Plantaginaceae, Caprifoliaceae.	Cyperaceae and Poaceae	Al-Teeb river floodplains, sM (Sandy mud)
3	Brassicaceae, Fabaceae, Caryophyllaceae, Euphorbiaceae, Boraginaceae, Salicaceae, and Xanthorrhoeaceae.	Cyperaceae and Poaceae	Al-Teeb river floodplains, sM (Sandy mud)
4	Amaranthaceae, Fabaceae, Zygophyllaceae, Ranunculaceae, Geraniaceae, Tamaricaceae.		Alluvial fan deposits, depression fill, and aeolian deposits.

			siS (Silty sand)
5	Fabaceae, Apiaceae, Brassicaceae, Lamiaceae, Caryophyllaceae, Papaveraceae, Plantaginaceae, Convolvulaceae, and Malvaceae.	Poaceae	Alluvial fan deposits, depression fill, and aeolian deposits. siS (Silty sand)
6	Fabaceae, Caprifoliaceae, Ranunculaceae, Boraginaceae, Plantaginaceae,	Poaceae	Sediments form a strip along the foothill zone and folded areas. siS (Silty sand)
7	Apiaceae, Brassicaceae, Lamiaceae, Convolvulaceae, Geraniaceae, Primulaceae, Capparidaceae, Boraginaceae, and Amaranthaceae.	Poaceae	Sediments form a strip along the foothill zone and folded areas. siS (Silty sand)
8	Lamiaceae, Amaranthaceae.		Floodplain sediments, with Sabkha as areas of salt accumulation. siS (Silty sand)
9	Tamaricaceae, Asteraceae, Zygophyllaceae, Amaranthaceae.		Floodplain sediments, with Sabkha as areas of salt accumulation. siS (Silty sand)

(**a**) (**b**)

Figure 4 a: *Halothamnus iraqensis* Botsch b: *Caroxylon jordanicola* (Eig) Akhani & Roalson.

The Asteraceae family is the most diverse in the number of its species. This is because the species of this family are the most able to withstand challenging environmental conditions such as lack of water and soil salinity [23, 24]. So, the species are found thriving and present as groups or as individuals spreading over close distances from each other, which is one of the characteristics that characterize most areas similar to this region, even when studying areas with less plant diversity found Species of this family are thriving in those areas [25, 26]. The other families' species are observed but smaller in number. Some plant families have recorded their presence in the Al-Teeb sites through one species per family, such as Caprifoliaceae, Capparidaceae, Euphorbiaceae, Solanaceae, Malvaceae and Primulaceae, Papaveraceae, Solanaceae, and Salicaceae. It is observed that some of these species reach a great height in some sites. This may be due to the harmony of the plant with its surrounding environment and the nutrients it needs for growth [27, 28].

Conclusions

The plant biodiversity in the Al-Teeb area indicates the presence of 114 dicotyledonous plant species belonging to 23 plant families and 39 monocotyledonous plant species belonging to 4 plant families.

A. The field surveys revealed that the following quaternary sediments are found in the Teeb area:

(1) The flat Flood Plain sediments consist of sand and clay with various percentages. It is distributed on both sides of the Teeb and Dewerage streams, reaching several meters in thickness. The Sabkhas soil exists due to high evaporation.

(2) Shallow depression and fill deposits less than one meter thick of clay, sand, and silt sediments.

(3) Sand Dunes and Sand sheets are spread over some parts of the Teeb area due to the aeolian processes, with thicknesses ranging from 1 to 5 m occurring parallel to Hemrin Mountain.

B. The texture analyses of the nine sites' sediment samples reflect that silt is a major part of the study area's sediment, where the Silt average is 49.6%, Clay average is 34.4%, and Sand average is 15.9%. According to the USDA texture, the average sediment classification is sandy silt (sSi).

C. The Al-Teeb area is distinguished by the variation in plant diversity, as they were very diverse in some sites. In contrast, others were less diverse depending on water availability, sediments, and soil types. The Plant samples are diagnosed at the family level of the study. The results recorded 114 dicotyledonous plant species and 39 monocotyledonous plants belonging to Amaryllidaceae, Cy-peraceae, Liliaceae, and Poaceae. The distribution of plant families is as follows:

(1) Al-Teeb River banks and floodplains area of Sandy mud (sM) sediment represented by sites 1, 2, and 3. It is of the fertility soil of mud, silt, and sand. It is characterized by the spread of dicotyledonous plants, especially the Amaranthaceae, Asteraceae, and Fabaceae families, the common species in that region. The monocotyledonous plants are also distributed in this area, with wide-spreading of the family Poaceae.

(2) Shallow depression and fill deposits of Silty sand sediment classification (siS) such as in sites 4 and 5. The following Dicotyledonous plant families are recognized Amaranthaceae, Fabaceae, Zygophyllaceae, Ranun-culaceae, Geraniaceae, Tamaricaceae, Apiaceae, Brassicaceae, Lamiaceae, Caryophyllaceae, Papa-veraceae, Plantaginaceae, Convolvulaceae, and Malvaceae.

(3) Sand sheets and Sand Dunes represent strips along the mountainous area and the foothill zone and are classified as Silty sand (siS). They are characterized by simple plant diversity, such as in sites 6 and 7. However, it was noted that the Poaceae family spread widely, as did Apiaceae, Brassicaceae, Lamiaceae, Convolvulaceae, Geraniaceae, Primulaceae, Cappari-daceae, Boraginaceae, Amaranthaceae, Fabaceae, Ranunculaceae, and Plantaginaceae.

(4) The Sabkha areas with salt accumulation within the Floodplain sediments are classified as Silty sand (siS). It is characterized by simple plant diversity, such as Lamiaceae, Tamaricaceae, Asteraceae, Zygophyllaceae, and Amaranthaceae as represented by sites 6 and 7.

Moreover, the Asteraceae family is the most diverse species due to its ability to withstand demanding environmental conditions such as lack of water and soil salinity. The other families' species are observed but in fewer numbers.

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