

Some Environmental And Biological Characteristics Of Ephemeral Pools In The State Of Kuwait

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Abstract: A study of the flora, fauna, environmental parameters and chemical analyses of water and sediment in 12 ephemeral pools in the State of Kuwait was conducted at various dates during 2013-2015 to assess their physical, chemical and biological characteristics. The flora in and around the pools was represented by 11 species of flowering gymnosperm plants belonging to 7 orders dominated by representatives of Caryophyllales in addition to one species of the genera *Rhizophora*. A total of 21 faunal species were found belonging to two phyla only; Arthropoda (Insecta, Crustacea and Arachnida) and Chordata (Amphibia and Pisces). The insects were represented by 5 orders with 15 species in various developmental stages in comparison with only two species of Crustacea and one species each for Arachnida, Amphibia and two species of Pisces. No significant differences were found between pools in most of their environmental characteristics except for salinity. Some pools showed higher values for sulphate concentration in the water and the soil due to receiving treated sewage water. Others had very high values of chloride and nitrate.

Key words: Kuwait, desert, ephemeral pools, Biota, chemistry

INTRODUCTION

Kuwait lies between the latitudes 28° 45' and 30° 05' north of the equator, and longitudes 46° 30' and 48° 30' east of GMT (Figure 1). Hence, it is situated in the geographically desert zone, which is marked by a continental climate. This climate is characterized by its long summer and short winter. Temperature may range between 45°C in summer and 6°C in winter, the annual rate of rainfall ranging between 22mm and 352mm. The highest temperature recorded in Kuwait was 51°C in July 1978, while the lowest was -4°C in January 1964. Rain in Kuwait occurred during the months of December, January and February. Although rain in Kuwait is sporadic, may on occasions be extremely heavy and result in areas of standing water, which will evaporate within days or weeks of summer. The evaporation of rainfall in Kuwait leads to a general upward of groundwater with increased concentration of soluble salts. During the year 2014, the annual rainfall was 107mm. most of the rain occurred during the months from November to January. Due to this high rainfall during this year, many ephemeral pools were established in the desert of Kuwait. Rain water was collected in lower basins and existed for only a short period then disappeared in summer; during their short life these pools may develop dense populations of a limited variety of species that survive the draught and extremes of temperature as resistant cysts or spores in the sand [1]. Ephemeral pools in Kuwait collected rain water and wind-blown sediment, forming tiny ecosystems where fascinating collection of plants and animals have adapted to life in the desert. Ephemeral pools in Kuwait vary in depth and length. Ephemeral or vernal pools or desert potholes are temporary aquatic microsystems that provide a habitat for distinctive plants and animals. They are type of wetland allow the safe development of natal amphibians and insect species

unable to withstand competition or predation fish, certain fish have however adapted to this habitat specifically. Ephemeral pools function as the primary sink for organic and inorganic matters in the desert landscapes [2]; ephemeral pools are widespread in arid and semi-arid regions [3]. Ephemeral pools are aquatic environment with no outlets so the water stays until it evaporates or absorbed into ground water or consumed by plants and animals when it is gone, it leaves behind plants and animals waiting for the pool to once again fill up with the water that gives them life. Animals of ephemeral pools are adapted for both aquatic and terrestrial habitats at different life stages, without seasonal pools, some species would not be able to compete and reproduce [4]. Most of the ephemeral pools of Kuwait occurred in the southern part of the country, in most of them, their water evaporated during February, but some may stay till the summer months. [5] studied the seasonal fauna of ephemeral saline pools in south Australia and recorded 16 species of Ostracods, nine species of Copepods, two species of Cladocera and one Amphipods, one Gastropod, one Nematode, one Polychaete and two Foraminifera, one Rotifer, in addition to Ciliates and Dipteran larvae. [1] were the first who mentioned ephemeral pools in Kuwait; they recorded two species of highly specialized crustaceans of brine shrimp. [6] gave an account of some aquatic Coleoptera of the north and south pools, they mentioned 15 species of beetles (eight from the south and seven species are common to both areas).

Materials and Methods

Study areas

Twelve ephemeral pools were visited, five pools (locations 1,2,3,4,5) where in Jula'a about 63 km south of Kuwait city, 47° 42' E and 28° 49' N, the first four

locations were in the desert and the fifth location was near the sea front, location 1,2,3 and 5 were full of desert vegetation only, while location 4 was full with desert vegetation, phragmites and algae because the treated sewage water was damped in this pool and mixes with rain water, this pool is a semi-permanent due to a continuous supply of treated water. Five pools (locations 6, 7, 8, 9, 10) were in Baidar about 75 km south of Kuwait city, 48° 14' E and 28° 52' N, the first four locations were in the desert and the last was near the sea front, location 6, 7 and 10 contain some desert vegetation, location 8 was devoted of vegetation while location 9 contain *phragmites* but not algae because untreated sewage water was damped in this pool (Figure 2). The last two pools (locations 11,12) were in North of Kuwait, location 11 was in Sulibikhat about 16 km from Kuwait city, 47° 51' E and 29° 19' N, location 12 was in Sulaibiyah about 115 km from Kuwait city, 48° 19' E and 29° 35' N (Figure 1), these pools were devoted of vegetation and animals. The Jula'a pools were approximately 20 cm in width, 117 cm in length and cm in depth, 80The Baidar pools were approximately 15 cm in length and 69 cm in depth. While Sulibikhat pool was approximately 10 cm in width, 10 cm in length and 30 in depth, devoted from vegetation. Sulaibiyah pool was approximately 20 cm in width, 30 cm in length and 15 cm in depth.

Periods of visits

Pools in locations 1-10 were visited five times, during the dates 8 February 2014, 24 April 2014, 20 November 2014, 27 November 2014 and on 5 February 2015. Pools in location 11 and 12 were visited only for one time on 23 February 2014.

Collection techniques

Co-ordinates were allocated by using GIS maps, depth, water temperature were recorded in sites, soil and water samples were collected and carried to Kuwait university for chemical analysis, Fauna were collected by using aquatic nylon nets and sieving plates.

Chemical analysis

Soil and water samples were tested in Faculty of science of Kuwait University laboratories, named the National Unit for Environmental Research and Services (NUERS) and Research Sector Project (RSP). Soil and water samples were tested for Mercury analysis by using Hg Analyzer Hydra-II, metal analysis by using ICP-OES GBC Quantima, anion analysis by using IC Dionex, ICS-5000, in addition the soil samples were tested for moisture content by using drying oven, Manufacturer – Binder Balance Manufacturer –Mettler Toledo and water samples were tested for turbidity by using Trilogy (Turner design) and salinity by titration method (USEPA 210).

Biota identification

The fauna and flora were recorded for each location by following special keys to identify aquatic fauna and flora.

Most of the vegetation in the pools is desert plants and some are mangrove, also algae were sampled in pools where rain water mixed with sewage water. The animals some are aquatic and some were collected near the banks and inside of the pools.

Results

Most of the rainfall in Kuwait occurred during 2013 was in May (37.93 mm), and November (63.21 mm), while during 2014 was in January (59.32 mm), a summary of the weather data is shown in Table 1). The highest average temperature during 2013 was in July (39.7 °C) and the lowest was in January and December (14°C) while the highest average temperature during 2014 was in August 38.28 °C) and the lowest was in January (12.90 °C), Figure3). The good rainfall produced many ephemeral desert pools in the south and north of Kuwait (photos 1), were full of vegetation and life (photo 3). The physical characteristics for water of the ephemeral pools (Table 2) showed that there is no great variation in temperature, it ranges between 14°C-22°C, salinity has great variations between pools, pool 1 has the greatest salinity with 101.37 ppt while some pools have the lowest with less than 10 ppt, turbidity showed some variations between pools, the highest was in pool 12 (87.07 114NUT), the lowest was in pool 10 (1.109 NUT).The chemical analysis of water (Table 3),showed that highest anion in pools water was chloride, with a total of 8139 ppm in pool 11, followed by pool 10 with 1138.9 ppm, the lowest chloride was found in pool 6 (0.836 ppm). The physical characteristic for soil (Tables 4), showed that the moisture content is almost the same in all pools, chemically the soil contain more anions than the water (Table 5),again the most abundant anion was chloride, the highest was 14956.40 ppm in pool 11, the lowest was 11.81 ppm in pool 9, the second abundant anion was nitrate, the highest was 35697.93 ppm in pool 11 and the second concentration was in pools 2 and 3, while the lowest 0.03 ppm was in pool 10. Flora and fauna of the ephemeral pools were classified and identified, plants (Table 6), the *phragmites* was mainly inside the pools with nutrients coming from sewage effluent, but still some desert plants were collected from inside and around the pools, most of the plants collected were from order Caryophyllales; the green algae recorded from location 4 were Rhizoclonium sp. (photo 3). Table 7, showed that most of the animals collected from the pools are insects (15 species) mainly beetles followed by flies, the *ephedra flavipes* was collected near the banks of the pools, crustaceans came after insects with only 2 species, one belong to order Anostraca and the other to order species belong to order Conchostraca and Anostraca. Mites, toads and fish were also collected from ephemeral pools in Kuwait.

Discussion

Ephemeral pools are unique isolated habitats in an otherwise dry landscape matrix that harbor organisms that are sensitive to water chemistry changes, temperature changes, sediment input and pH changes.

They are occurring naturally forming tiny ecosystem with fascinating collection of plants and animals that have been adapted to life in desert pools; they support wild life that would not be successful in permanent waters [4], [7], [8]. [6] published a preliminary account of beetles in ephemeral pools in Kuwait; they recorded eight species from the southern pools. *Artimia* occurs in many pools of water with any salt content including desert regime [9]. [1] found the brine shrimp, *Artimia salina* in desert pools of Kuwait. *Eulimnadia* inhabit ephemeral water [10], [4] found fairy shrimp, clam shrimp, small crustaceans such as water fleas *Daphnia*, aquatic insects such as beetles, dragonflies, damselflies, water bugs, true flies and mosquitoes in Michigan vernal pools. [11] reported that small number of reptiles and mammals also utilize ephemeral pools during wet phase. Ephemeral pools in Kuwait is a unique aquatic ecosystem that harbor many wild life and contribute significantly to biodiversity, they are vulnerable for destruction due to human activities.

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Table 1. Weather summary during the years 2013 – 2014

Year	Month	Ave. Temperature (° C)	Min Temperature (° C)	Max Temperature (° C)	Wind Speed (Km/H)	Wind direction	Humidity %	Total Rain fall (mm)
2013	Jan	14	1.1	25	42.12	SE	61	5.86
	Feb	17.3	7	29.2	43.56	SE	61	0.57
	Mar	21.7	7.1	36.6	53.64	SE	61	2.69
	Apr	26.2	13.3	38.6	54.72	SE	55	0.12
	May	31	19.1	45.2	48.60	N	55	37.93
	Jun	37.4	26.3	47.2	55.80	N	49	
	Jul	39.7	26.6	50.5	46.44	NW	41	
	Aug	37.9	26.5	48.6	41.40	N	46	
	Sept	34.3	17.2	47.5	46.08	N	51	0.12
	Oct	26.3	11.2	43.2	45.72	N	60	0.21
	Nov	20.9	11.8	31.1	38.16	SE	59	63.21
	Dec	14	1.6	28.6	45.72	NW	65	8.34
2014	Jan	12.9	4.2	22.1	49.32	NW	49.32	59.32
	Feb	14.4	1.6	27.8	48.60	NW	48.60	3.71
	Mar	20.9	9.1	33	58.32	SE	58.32	5.82
	Apr	27.8	8.9	40.3	47.16	N	47.16	2.35
	May	33.15	25.68	40.62	43.48	NW	43.48	3.8
	Jun	37.35	29.07	45.64	51.50	NW	51.50	
	Jul	36.75	31.19	42.32	55.90	NW	55.90	
	Aug	38.28	30.55	46	58.31	NW	58.31	
	Sept	35.5	27.4	43.6	51.00	NW	51.00	
	Oct	29.36	22.23	36.5	48.48	NW	48.48	3.3
	Nov	19.5	12.7	26.3	55.40	NW	55.4	13.8
	Dec	15.8	8.4	23.2	63.30	NW	63.30	17.3

Table 2. Physical characteristics of water in Kuwait desert ephemeral pools

Location	Temperature (° C)	Salinity (ppt)	Turbidity (NUT)
1	14	101.37	33.09
2	16	61.91	20.76
3	16	18.58	21.25
4	19	<10	27.68
5	15	38.73	25.797
6	21	13.20	10.4
7	22	16.87	10.40
8	22	<10	9.50
9	22	<10	2.80
10	21	23.83	1.109
11	17	13.28	26.84
12	20	<10	87.07

Table 3. Chemical characteristics of water in Kuwait desert ephemeral pools

Location	Fluoride (ppm)	Chloride (ppm)	Bromide (ppm)	Nitrate (ppm)	Phosphate (ppm)	Sulphate (ppm)	Hg in ppb
1	< 0.1	635	< 0.1	< 0.1	8.20	< 0.1	1.3983
2	< 0.1	365	< 0.1	< 0.1	26.10	< 0.1	0.5587
3	< 0.1	564	< 0.1	< 0.1	16.90	< 0.1	<0.2
4	< 0.1	865	< 0.1	< 0.1	17.20	< 0.1	<0.2
5	< 0.1	85	< 0.1	< 0.1	15.30	< 0.1	<0.2
6	< 0.1	0.836	3.47	< 0.1	0.151	0.120	0.419
7	0.26	768.16	3.86	0.03	0.00	233.37	1.426
8	0.20	327.51	1.47	0.10	0.00	173.49	0.806
9	0.16	309.79	1.51	<.001	0.00	142.91	2.319
10	0.36	1138.9	5.63	0.04	0.00	273.61	1.249
11	< 0.1	8139	< 0.1	< 0.1	5.24	< 0.1	< 0.2
12	< 0.1	340	< 0.1	< 0.1	41.40	< 0.1	< 0.2

Table 4. Physical characteristics of Soil in Kuwait desert ephemeral pools

Location	Moisture Content %
1	33
2	23
3	19
4	8
5	9
6	26.2
7	30.6
8	40.8
9	33.5
10	35.9
11	36.48
12	16.48

Table 5. Chemical characteristics of soil in Kuwait desert ephemeral pools

Location	Fluoride (ppm)	Chloride (ppm)	Bromide (ppm)	Nitrate (ppm)	Phosphate (ppm)	Sulphate (ppm)	Hg in ppb
1	< 0.1	3644	48.00	14351	80.00	< 0.1	0.4096
2	< 0.1	6116	68.50	25340	201.60	< 0.1	0.4118
3	< 0.1	6468	< 0.1	23541	20.90	< 0.1	0.7009
4	< 0.1	8077	62.20	16432	17.20	< 0.1	0.7506
5	< 0.1	1091	< 0.1	3.56	85.30	< 0.1	0.8047
6	0.060	60.35	0.20	1.918	< 0.1	15.76	< 0.2
7	0.02	19.82	0.08	0.04	0.00	46.78	< 0.2
8	0.03	13.19	0.05	0.15	0.00	70.13	< 0.2
9	0.02	11.81	0.04	0.06	0.00	141.86	< 0.2
10	0.05	29.69	0.11	0.03	0.00	130.07	< 0.2
11	0.80	14956.40	71.58	35697.93	31.89	< 0.1	ND
12	1.07	71.55	59.07	2.17	33.08	14.95	ND

ND = Not Detected

Table 6: Flora in and around Kuwait desert ephemeral pools during the year 2014

Order	Family	Species
Malpighiales	Rhizophora	<i>Lanuae mucronata</i>
Asterales	Asteraceae	<i>Senecio glucus</i>
Caryophyllales	Tamaricaceae	<i>Tamarix aucheriana</i>
Caryophyllales	Amaranthaceae	<i>Sueda vermiculata</i>
Caryophyllales	Amaranthaceae	<i>Cornulaca aucheri</i>
Caryophyllales	Amaranthaceae	<i>Halocnemum strobilacium</i>
Caryophyllales	Armaranthaceae	<i>Chenopodium murale</i>
Malvales	Malvaceae	<i>Malva pariflora</i>
Zygophyllales	Zygophyllaceae	<i>Zygophyllum qatarse</i>
Poales	Poaceae	<i>Phragmites australis</i>
Unplaced	Poraginaceae	<i>Arnebia decumbens</i>

Table 7: Fauna in Kuwait desert ephemeral pools during the year 2014

Class	Order	Family	Species	Stage		
Insecta	Ephemeroptera	Baetidae	<i>Cloeon dipterum</i>	Adult		
	Odonata	Libellulidae	<i>Crocothemis servilia</i>	Nymph		
	Hemiptera	Corixidae	<i>Sigara lateralis</i>	Adult & Nymph		
			<i>Heliocorisa vermiculata</i>	Adult & Nymph		
	Diptera	Chironomidae	<i>Ablabesmyia</i> sp.	Larva		
			<i>Chironomus attenuatus</i>	Larva		
			Ephydriidae	<i>Ephydra flavipes</i>	Adult & Larva	
			Culicidae	<i>Culex pipiens</i>	Adult & Larva	
			Empididae	<i>Hemerodromia</i> sp.	Larva	
			Coleoptera	Dytiscidae	<i>Herophydrus musicus</i>	Adult & Larva
					<i>Hydroporus solieri</i>	Adult
				Hydrophilidae	<i>Berosus bispina</i>	Larva
	<i>Enochrus ater</i>	Adult (Soil				
	Dytiscidae	<i>Agabus consperus</i>			Larva	
	<i>Hygrotus inscriptus</i>	Adult				
	Crustacea	Anostraca	Artemiidae	<i>Artemia salina</i>	Adult	
Conchostraca		Limnadiidae	<i>Eulimnadia diversa</i>	Adult		
Arachnida	Acari	Hydrachnidia	<i>Limnesia</i> sp.	Adult		
Amphibia	Sallentia	Bufo	<i>Bufo viridis</i>	Adult		
Fish	Perciformes	Cichlidae	<i>Tipalia niletica</i>	Adult		
		Sparidae	<i>Sparidentex hasta</i>	Adult		

Fig. 1: Location of Kuwait and the study areas in desert of Kuwait

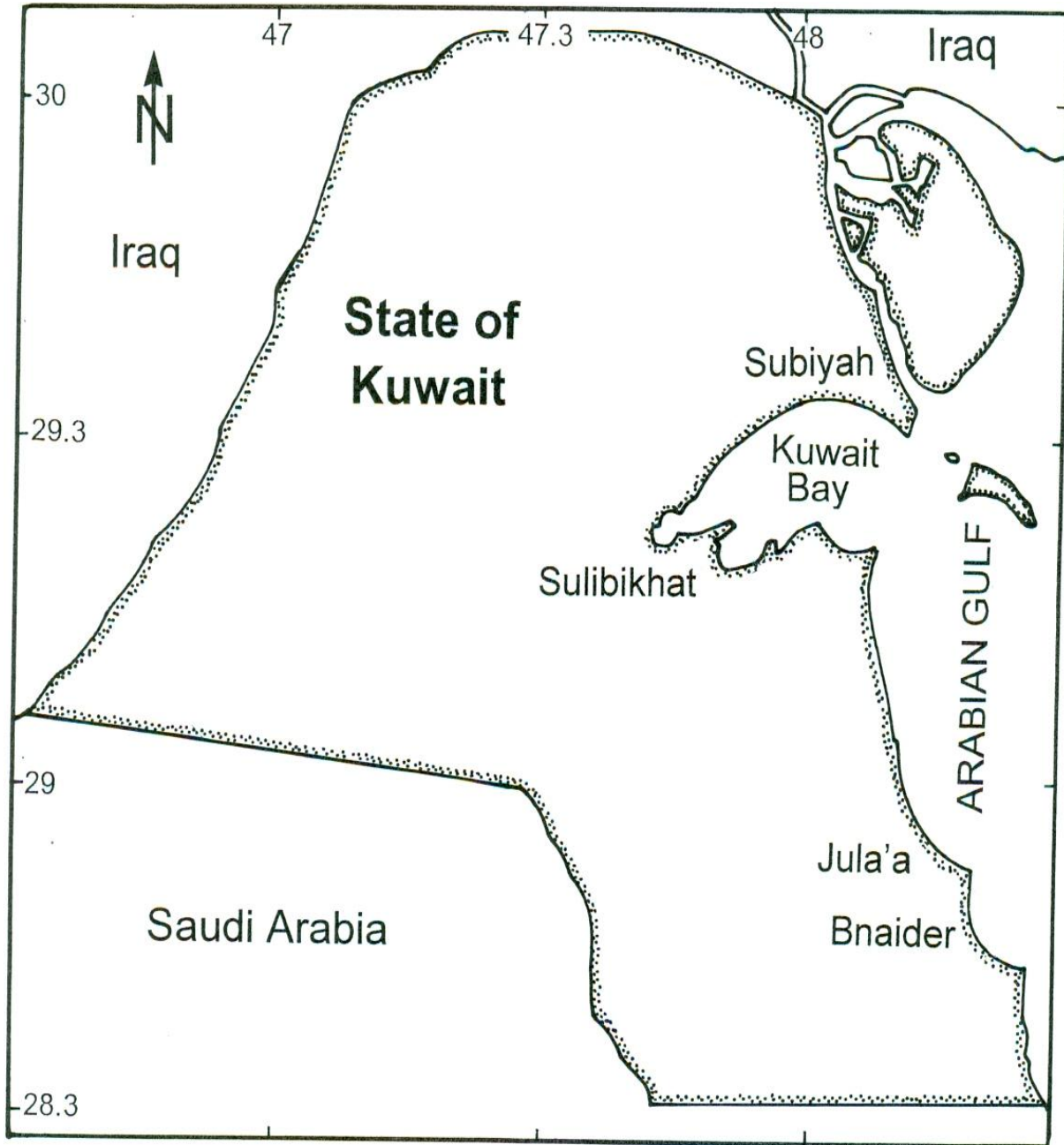


Fig. 2: Location of southern ephemeral pools in Kuwait

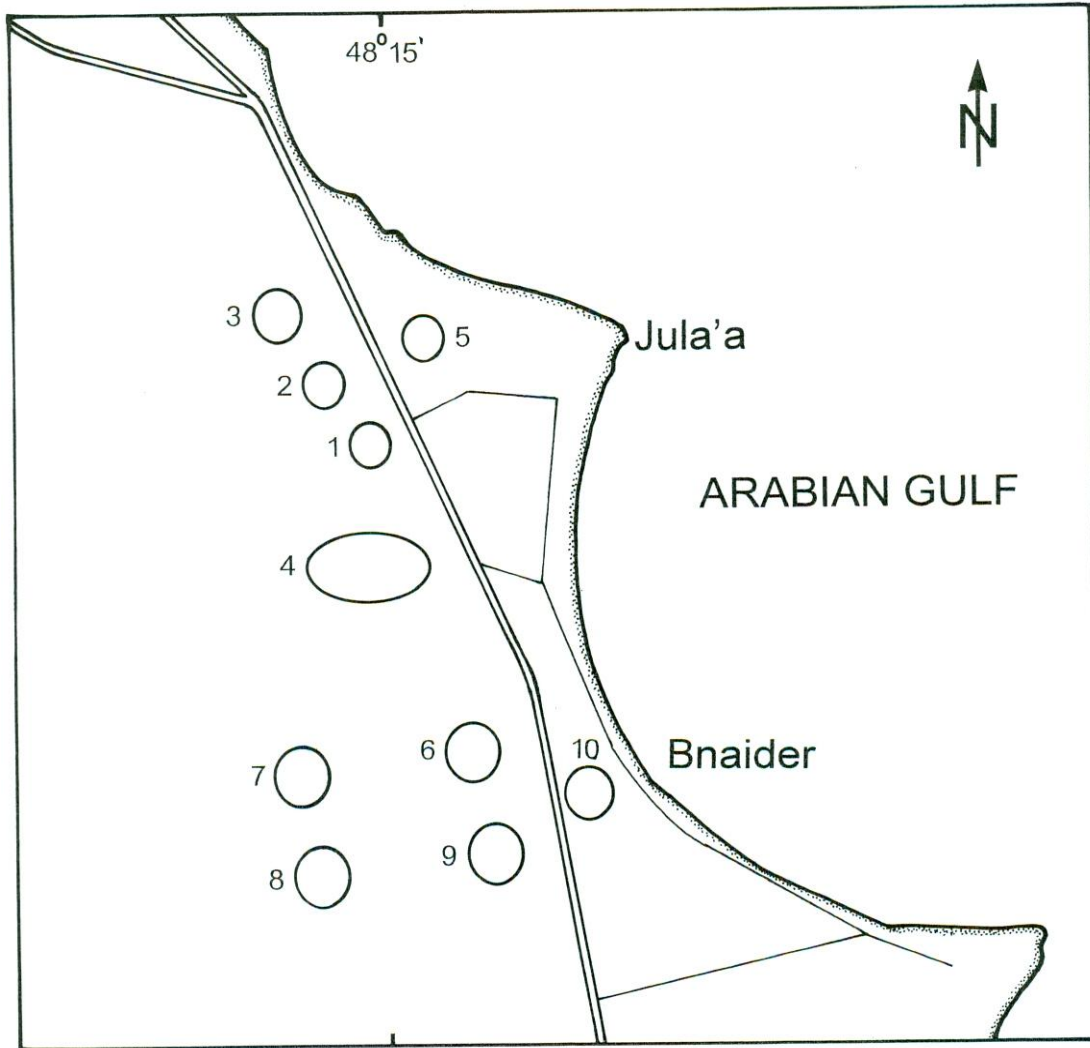


Fig. 3: Maximum temperature, humidity, rainfall and wind speed during the years 2013 -2014

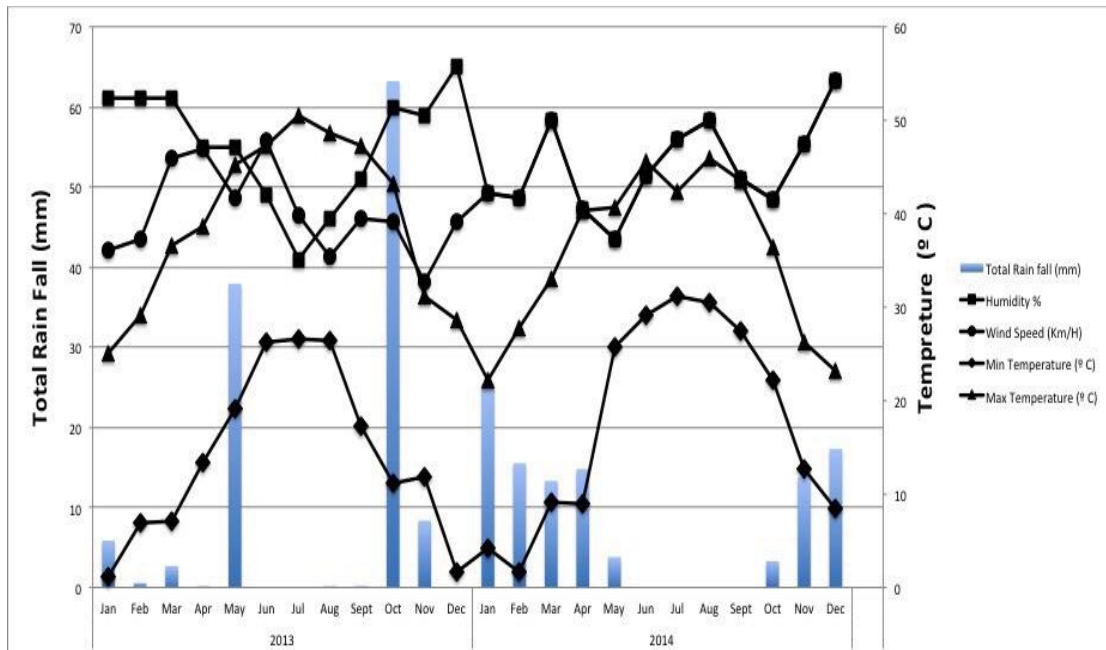


Photo 1: *Jula`a pools (Location 5)*

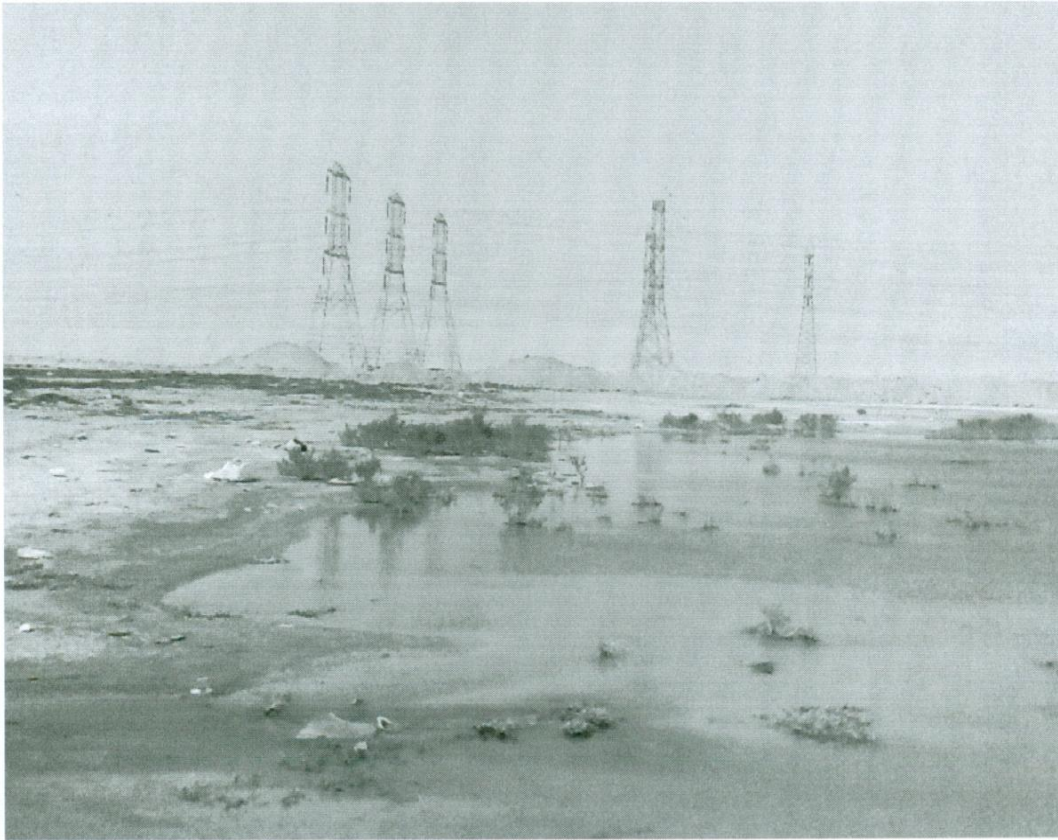


Photo 2: *Sulibikhat pools (Location 11)*



Photo 3: *Vegetation in location 4 (south of Kuwait)*

