Investigations of Upper Most Soil Zone Characterization and its Impact on Recharging the Shallow Groundwater Aquifer in Arid Region: A Case Study on Wadi Al Bih Dam, Ras Al Khaimah, Northern Emirates, United Arab Emirates (UAE)

Ahmed Murad, Saber Mahmoud, Hasan Arman,
Amir Gabr & Abdulla Al Dhuhoori

UAE University

Overview

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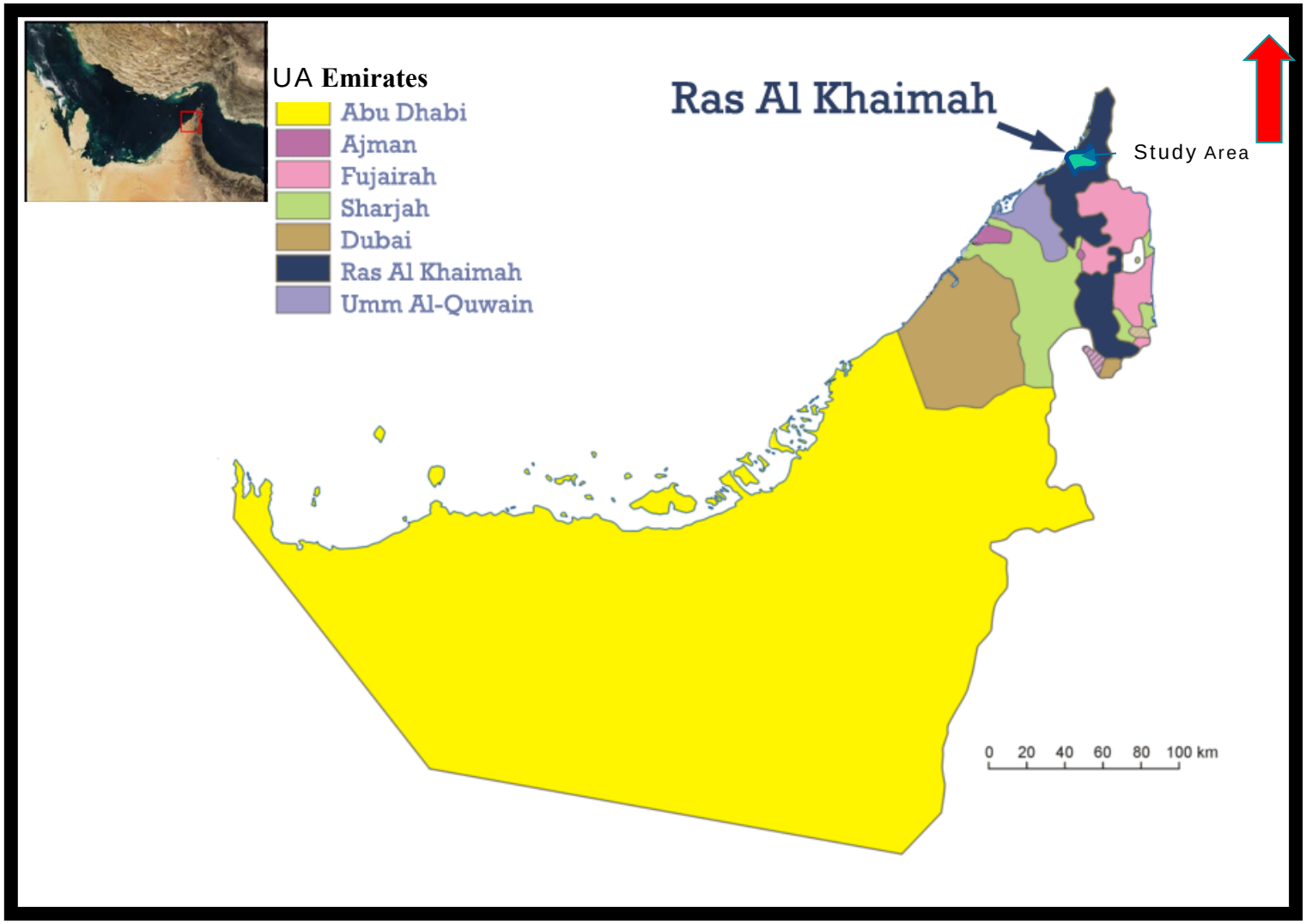
Introduction

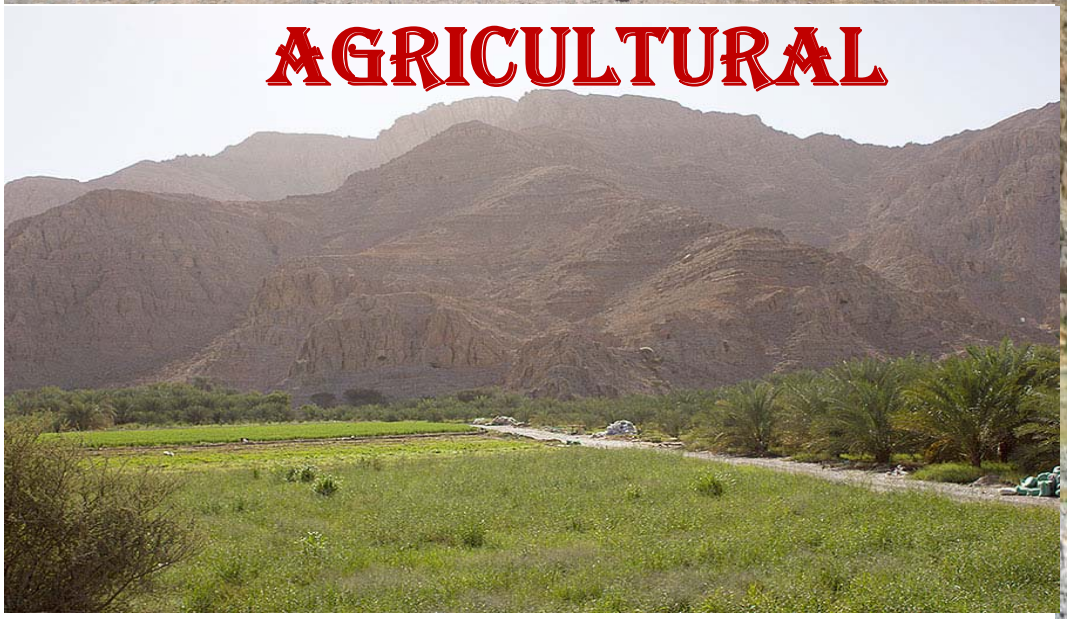
- The study area is located on the northeastern part of the United Arab Emirates .
- The area is characterized by the predominance of geomorphologic features such as mountains, gravel plains, and drainage basins.
- Dams were constructed to harvest the rainwater, protect the environmental system and recharge the aquifers.
- The water use is concentrated in domestic, agricultural, industrial and touristic purposes.

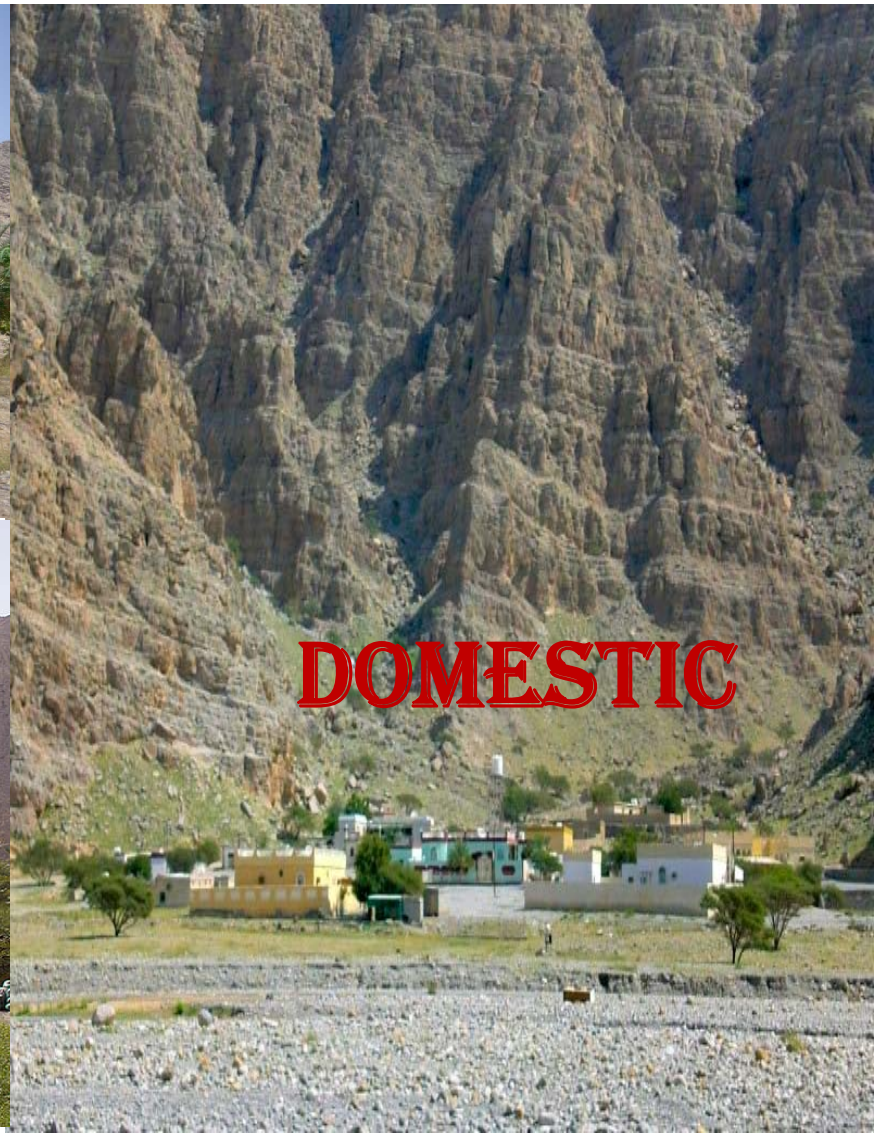
Location Map of the Study Area



Water Uses

AGRICULTURAL





Water Uses

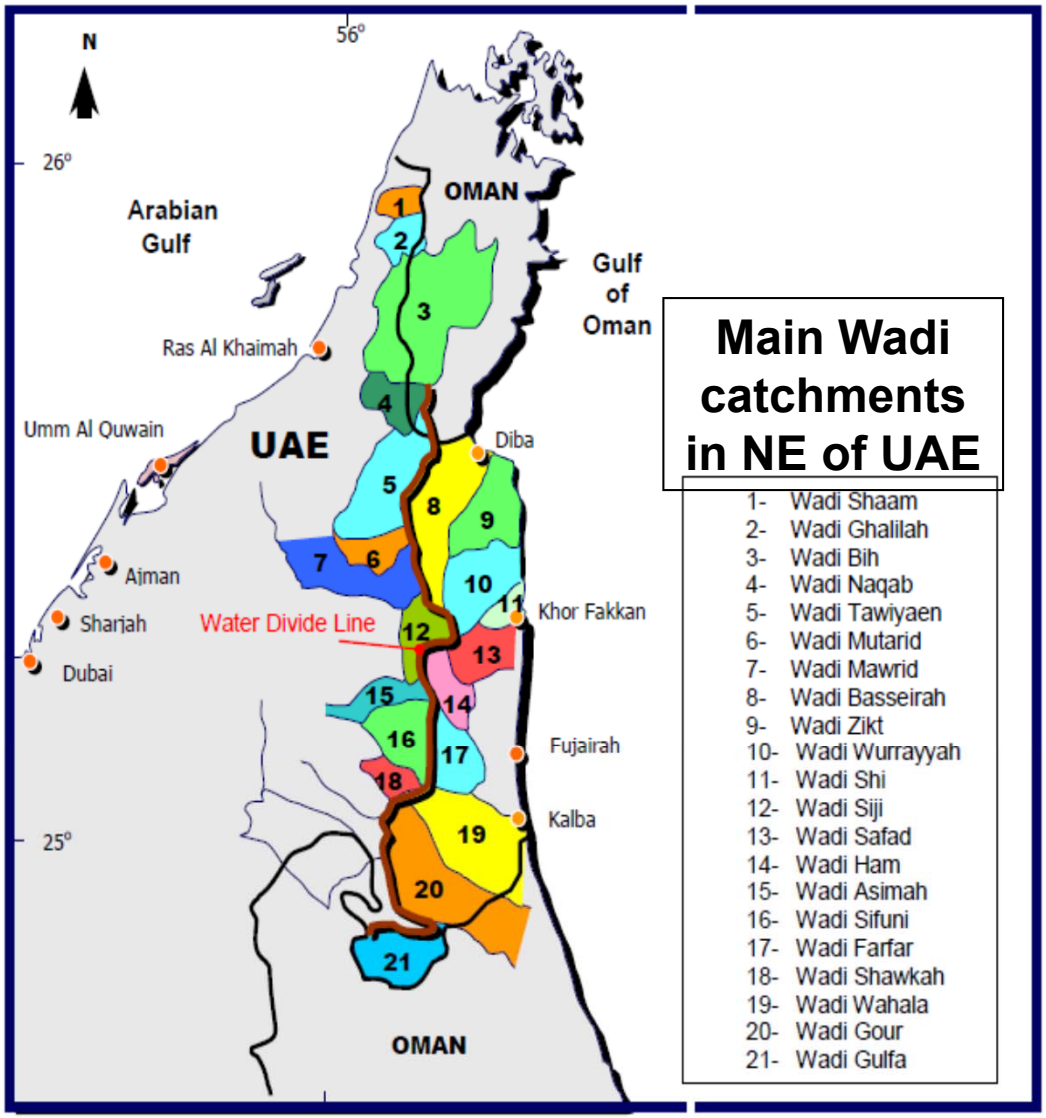
Objective

- The main task of this study is to tackle the Investigation of the upper most soil zone textural characterization using double Ring and open Pit infiltration tests to show its ability to absorb the surface water and recharging the shallow groundwater aquifers in wadi Al Bih Dam.

Geomorphology

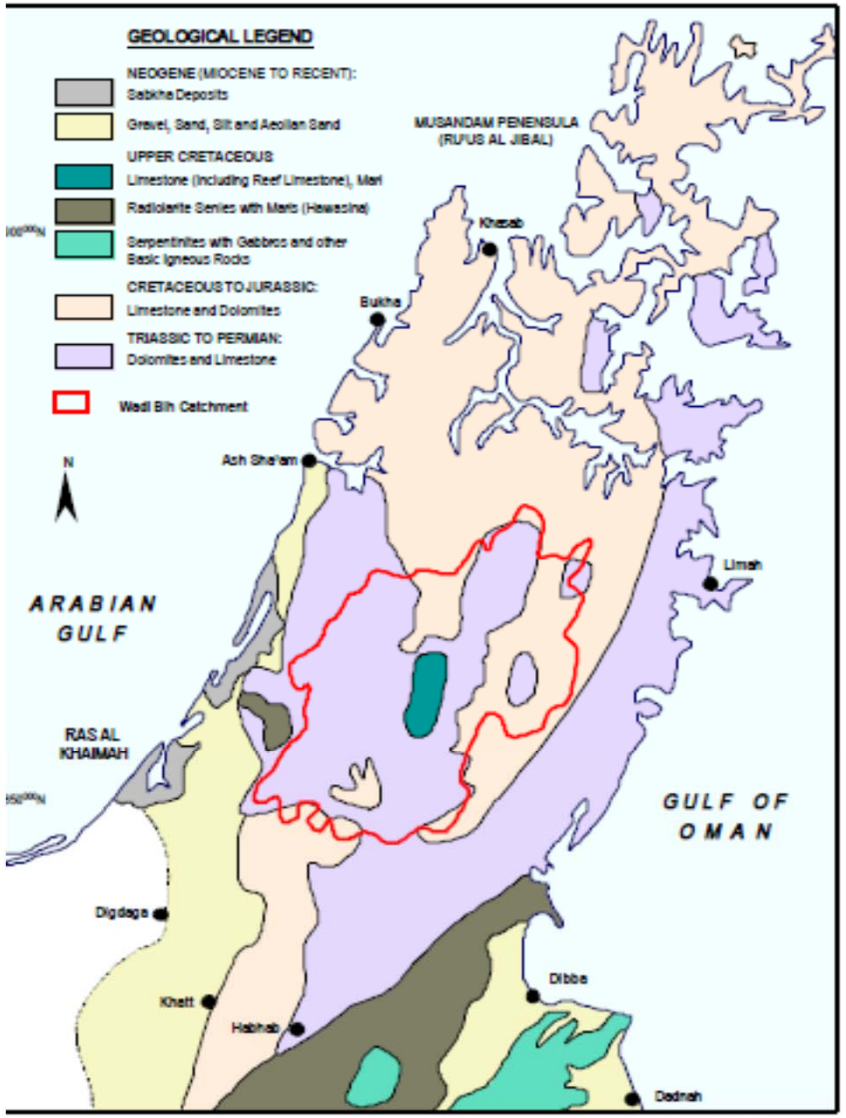
The principal geomorphic regions in the UAE

Geomorphology



Main Wadi catchments in NE of UAE

1- Wadi Shaam
2- Wadi Ghalilah
3- Wadi Bih
4- Wadi Naqab
5- Wadi Tawiyaen
6- Wadi Mutarid
7- Wadi Mawrid
8- Wadi Basseirah
9- Wadi Zikt
10- Wadi Wurrayyah
11- Wadi Shi
12- Wadi Siji
13- Wadi Safad
14- Wadi Ham
15- Wadi Asimah
16- Wadi Sifuni
17- Wadi Farfar
18- Wadi Shawkah
19- Wadi Wahala
20- Wadi Gour
21- Wadi Gulfa



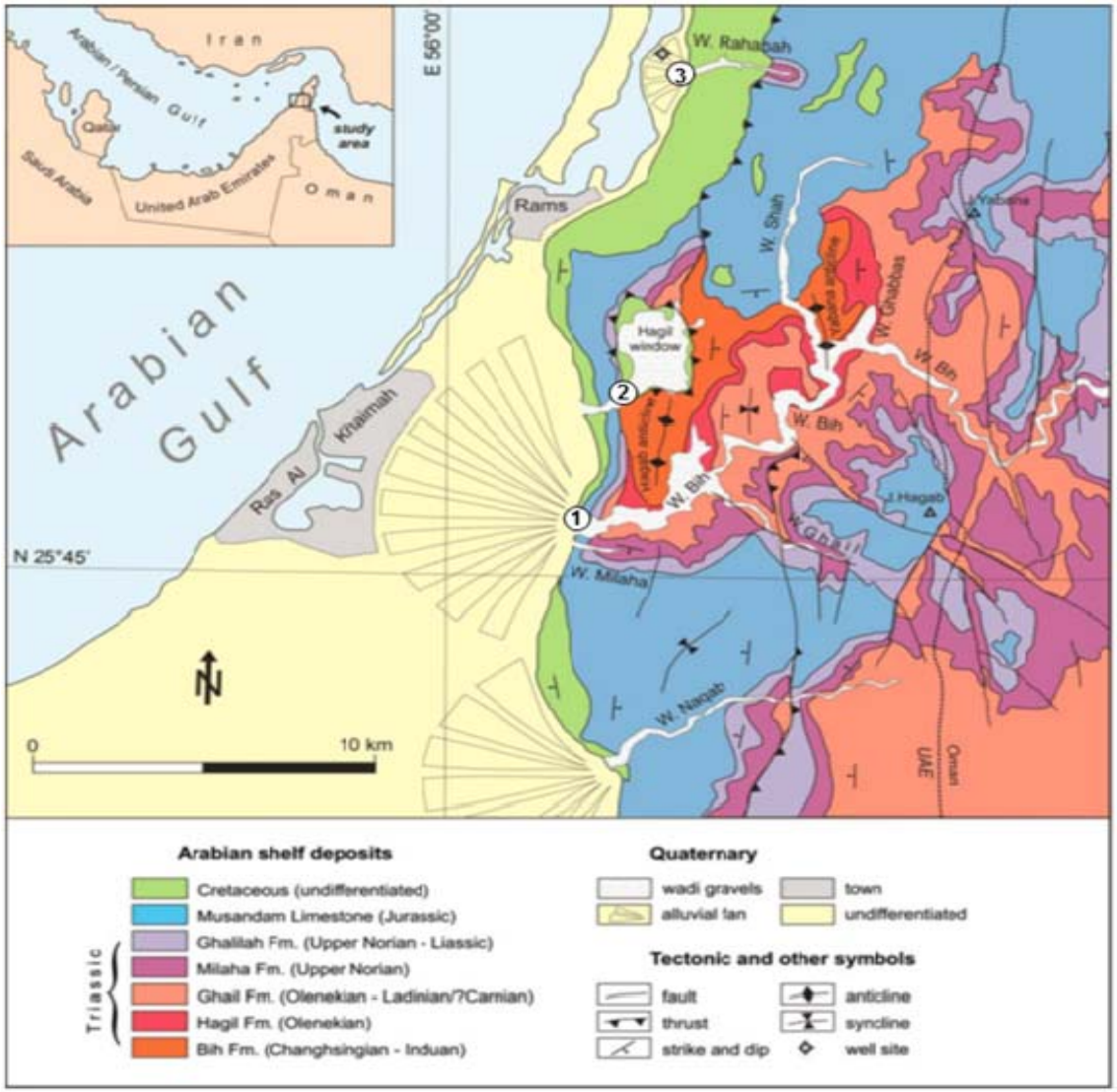
Wadi Al Bih study area consists of a widespread network of valleys of surface area of 483 km^2

Geomorphology

- The Wadi Al Bih drainage basin described by a rugged topography with steep slopes and its catchment area underlain by limestone.
- The minimum and maximum elevation is 65 and 2087 m above mean sea level (amsl) respectively.
- The drainage net of Wadi Al-Bih basin is external, well developed, and mostly controlled by geologic structures.

Geological Setting

Composed of Permian to Mesozoic shallow-water, carbonates that are exposed in a couple of west-verging thrust sheets.



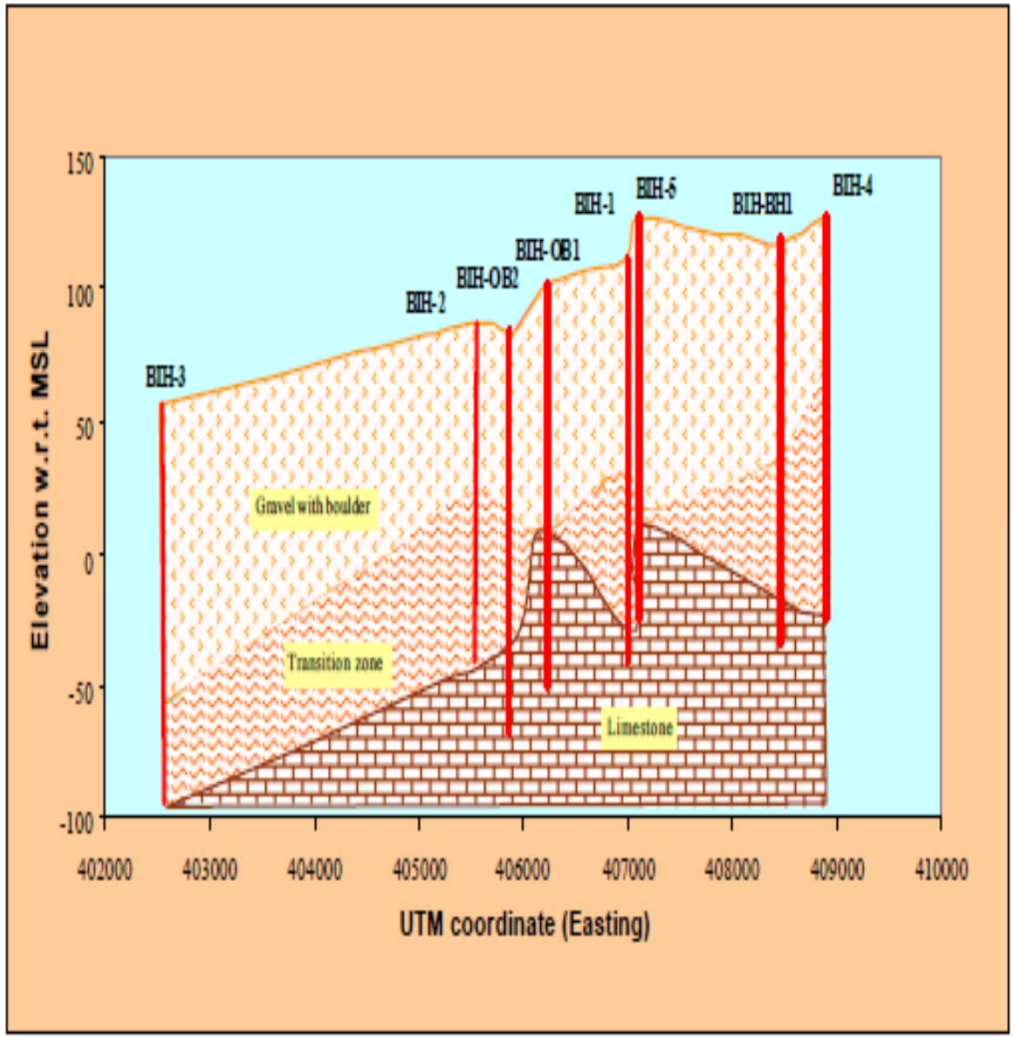
Geological map of the Study Area

Hydrogeology

Main groundwater aquifers in UAE

Aquifer Characterization

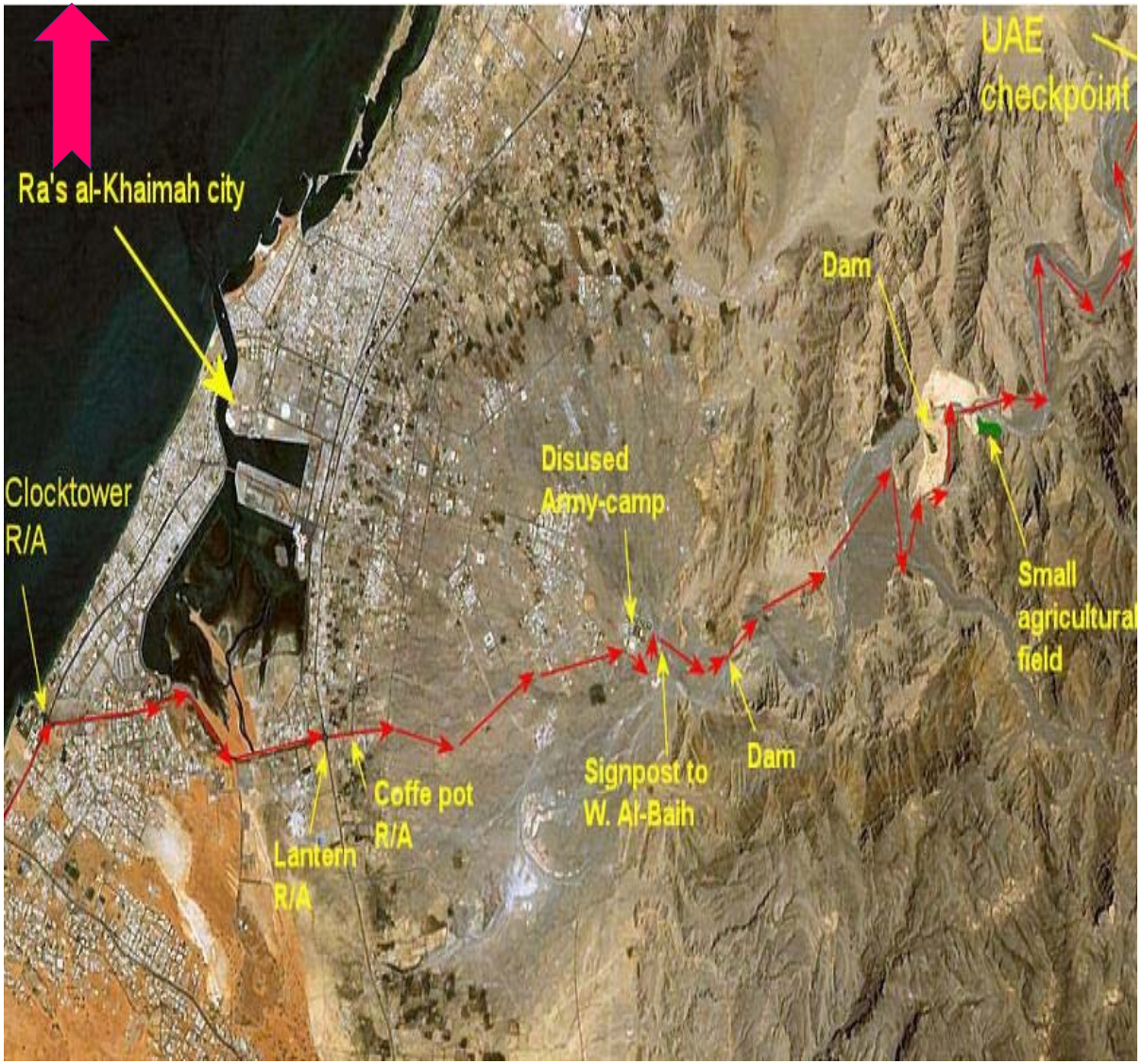
- Upper gravel layer of loose, coarse, and very permeable alluvial gravels of carbonate origin.
- And lower unit of fractured limestone.
- Vertical hydraulic conductivity of the alluvial gravel ranges from 10 m/day to 0.1 m/day.
- Lateral hydraulic conductivity varies from 32 to 67 m/day.



Cross section in the Study Area

Hydrogeology

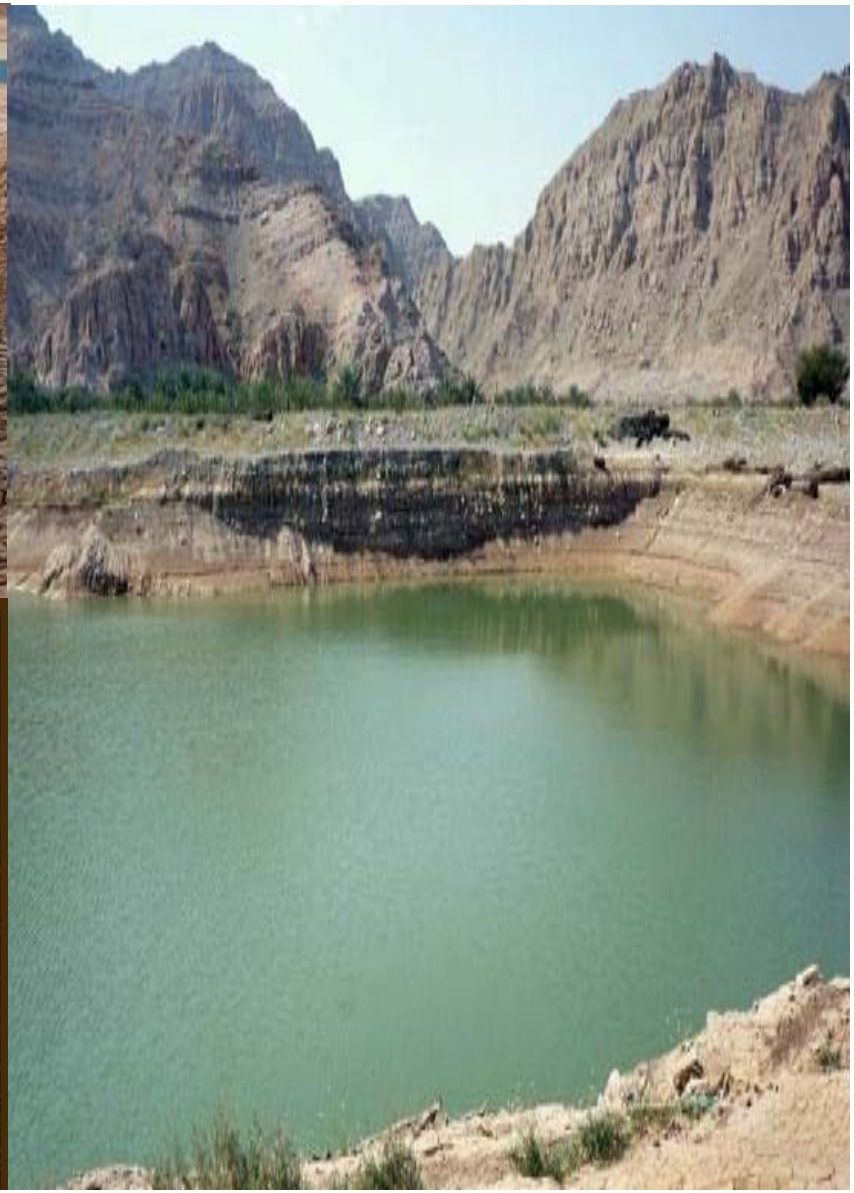
- Most of the natural recharge to the aquifer is received at the heads of alluvial fans by infiltration form Wadi's flows originated in the watershed zone.
- Approximately 10% of the annually rainfall recharges aquifers .



Satellite image image of Wadi Bih

Flash floods of Wadi Al Bih

Surface Lakes after flash floods along Wadi Al Bih



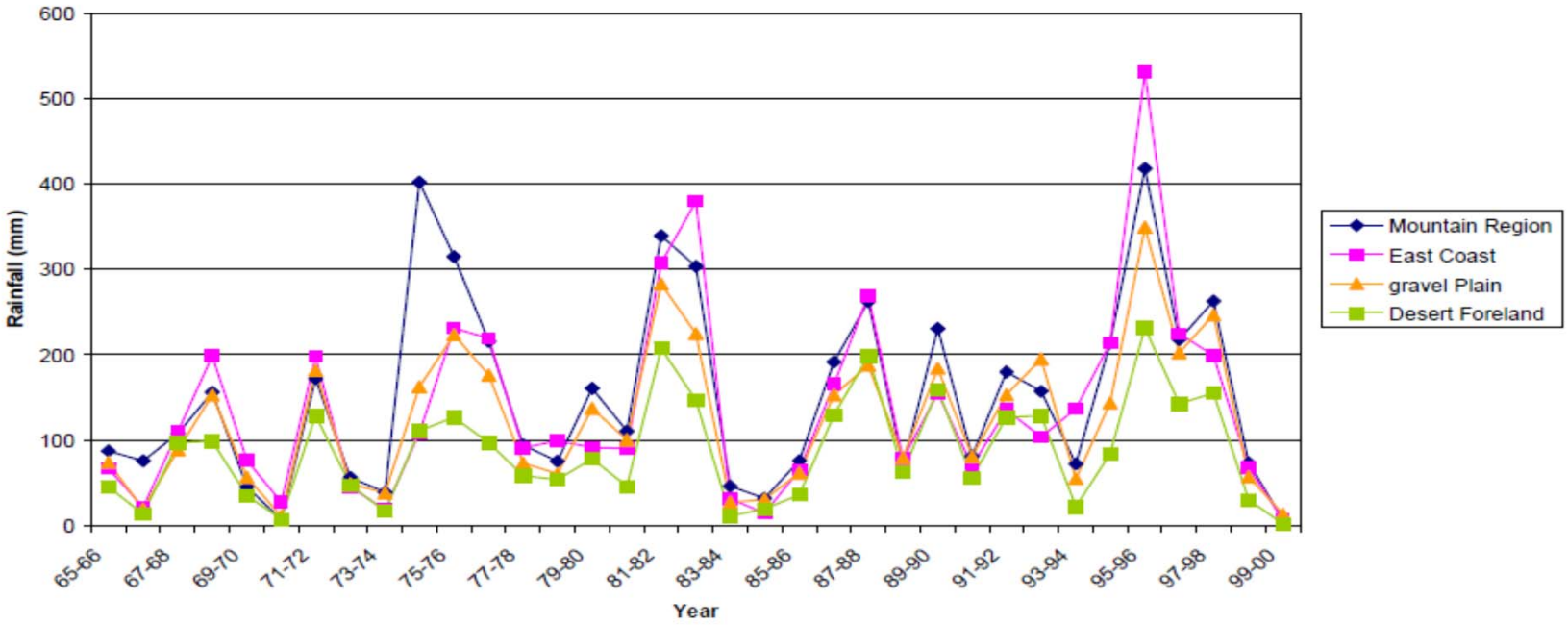
Dam of Wadi Al-Bih reduced the flash flood hazard and consequently increased groundwater recharge potentiality around the dame area

Flood water volume stored in dam reservoirs from 1990 to 2001 in million m^3 (after Al-Asam, 2003)

Catchment	Bih	Ham	Idhn	Gulfa	Hadf	Wurayyah
1990	1.150	4.870	0.500	0.165	-	-
1991	1.030	0.490	0	0.062	-	-
1992	3.300	0.120	0.67	0.192	0.542	-
1993	2.000	1.520	0.509	0.200	0.700	-
1994	-	0	0.40	0.102	0.250	-
1995	4.760	1.050	2.060	0.537	1.375	-
1996	2.350	0	1.080	1.150	2.675	-
1997	1.890	3.105	0.270	0.920	1.125	0.550
1998	8.150	0.650	0.370	0.300	0.400	0.150
1999	0.650	1.500	-	-	-	0.500
2000	-	-	-	-	0.50	0.500
2001	0.500	-	0.500	-	-	0.250
Total	***25.78***	***13.305***	***6.359***	***3.628***	***7.567***	***1.95***

Climatic Conditions

- UAE has an arid climate with very high temperature and rarely rainfall in summer.
- In winter, temperatures are generally between 14°C and 23°C.
- > 80% of the annual rainfall occurs during winter months.
- Rainfall averaging 120 mm/year .
- Temperature annual mean value is 27.7°C



Average annual rainfall (mm) for the UAE for the period 1965-66 to 1999-2000 (MAF, 2001b)


Snow fell heavily on the mountains of Ras Al Khaimah on Friday night, leaving it covered in a thick blanket of white.
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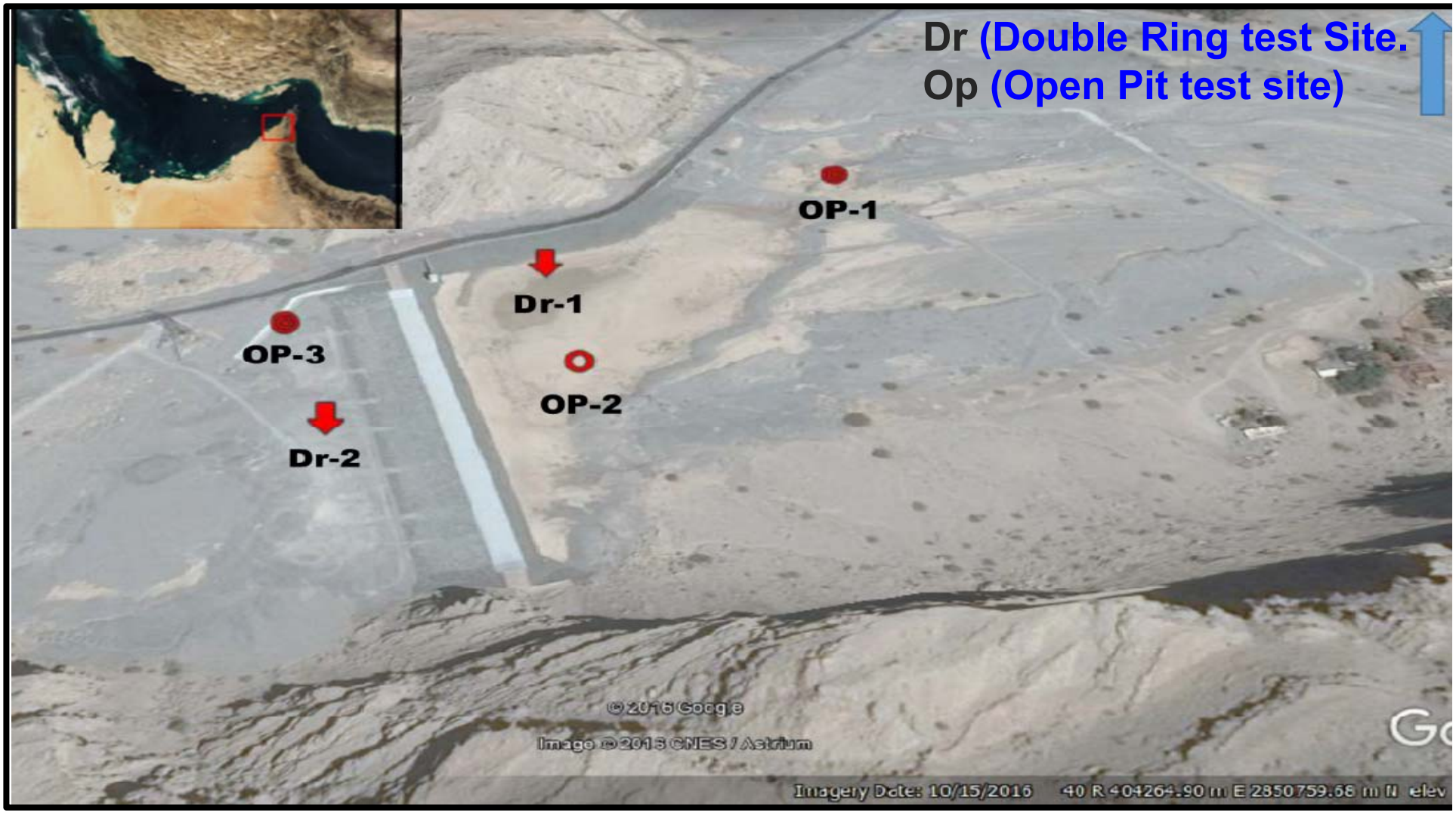
Materials and Methods

- **Five sites were selected for performing two double ring infiltration tests and three open pit tests on both upstream and downstream of dam .**
- **One double ring and two open pits were carried out in the dam upstream .**
- **One double ring and open pit were conducted in the dam downstream.**
- **eventually, field data of each test was graphically represented in order to visualize sediment behavior with respect to the infiltration rate.**



Location map of the study area (Wadi Al Bih dam, Ras Al Khaimah, UAE)

Increment infiltration rate measurements were performed based on ASTM standards using double ring device of 30 cm diameter (inner ring) and 60 cm (outer ring).

The open pit infiltration test were done manually by recoding the elapsed time and the total depth of water seepage inside the pit

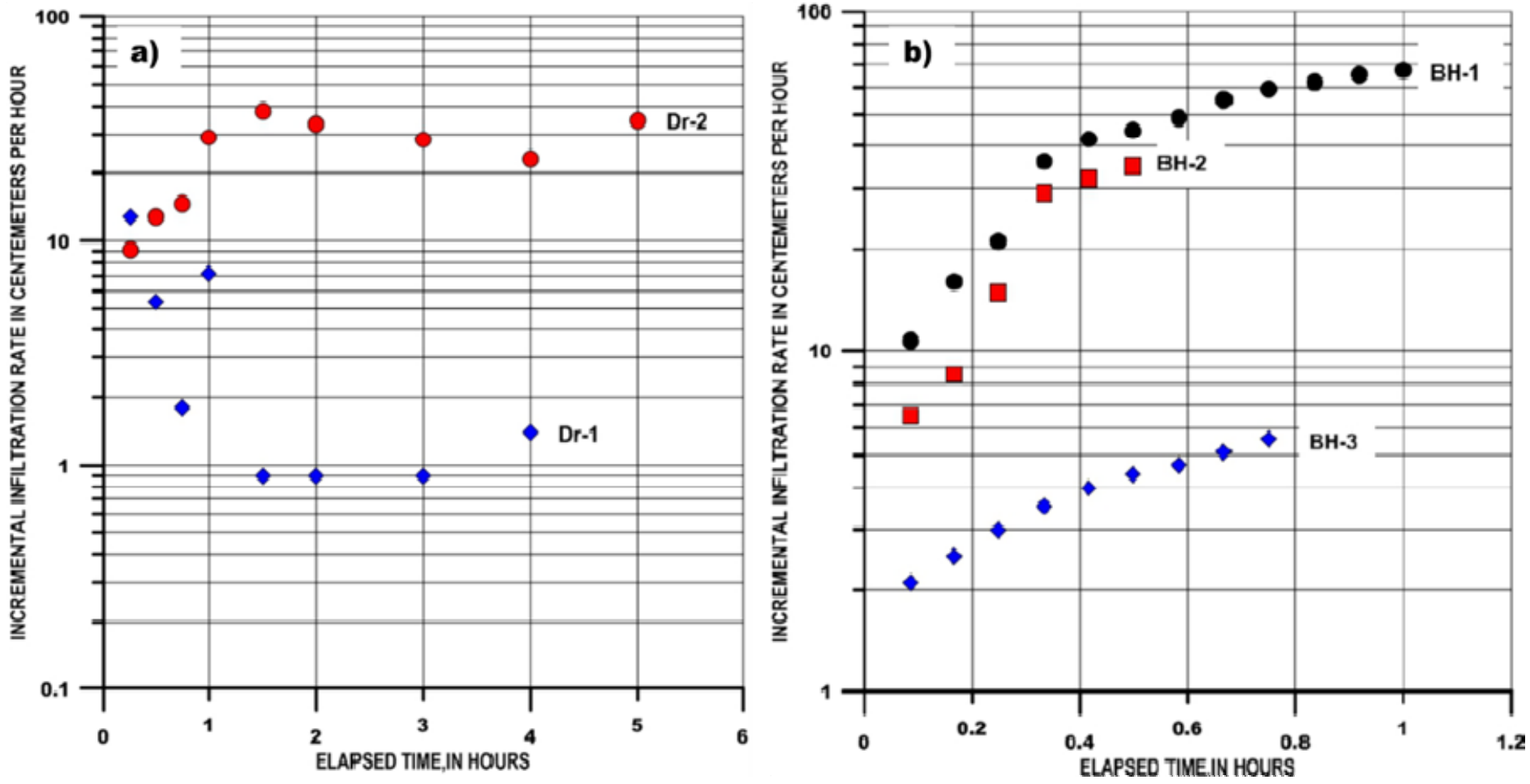
Sediment information for each site was obtained from field description as well as laboratory sieve analysis of eleven sediment samples were collected from all the tested locations.

Results and Discussions

- The infiltration rates and exhibits values ranging between 3.9 to 25 cm/hr .
- while the recorded infiltration test results from the open pits reveal values vary from 2.5 to 67.3 cm/hr in the upstream and downstream of the dam respectively.
- The overall tests including double ring and open pit average results ranges between 9.9 to 46.2 cm/hr.
- The infiltration capacity displays a reversible trending of increase and decrease on both sides of the dam which was of higher values in the downstream side (Dr-2) and lower in the upstream (Dr-1)-a.

Results and Discussions

- The open pit (OP-1 and 3) infiltration results have the identical response whereas, the OP-1 reflects higher values and OP-2 and 3 show lower ones –b.
- Sieving technique showed variability in the grain sizes dominated by poorly graded sand with gravel in all test sites except the location of OP-1 that exhibits poorly graded sand (a-b).
- These variations in the texture are apparently belongs to the lithological constituents and to the geomorphological conditions a-b.

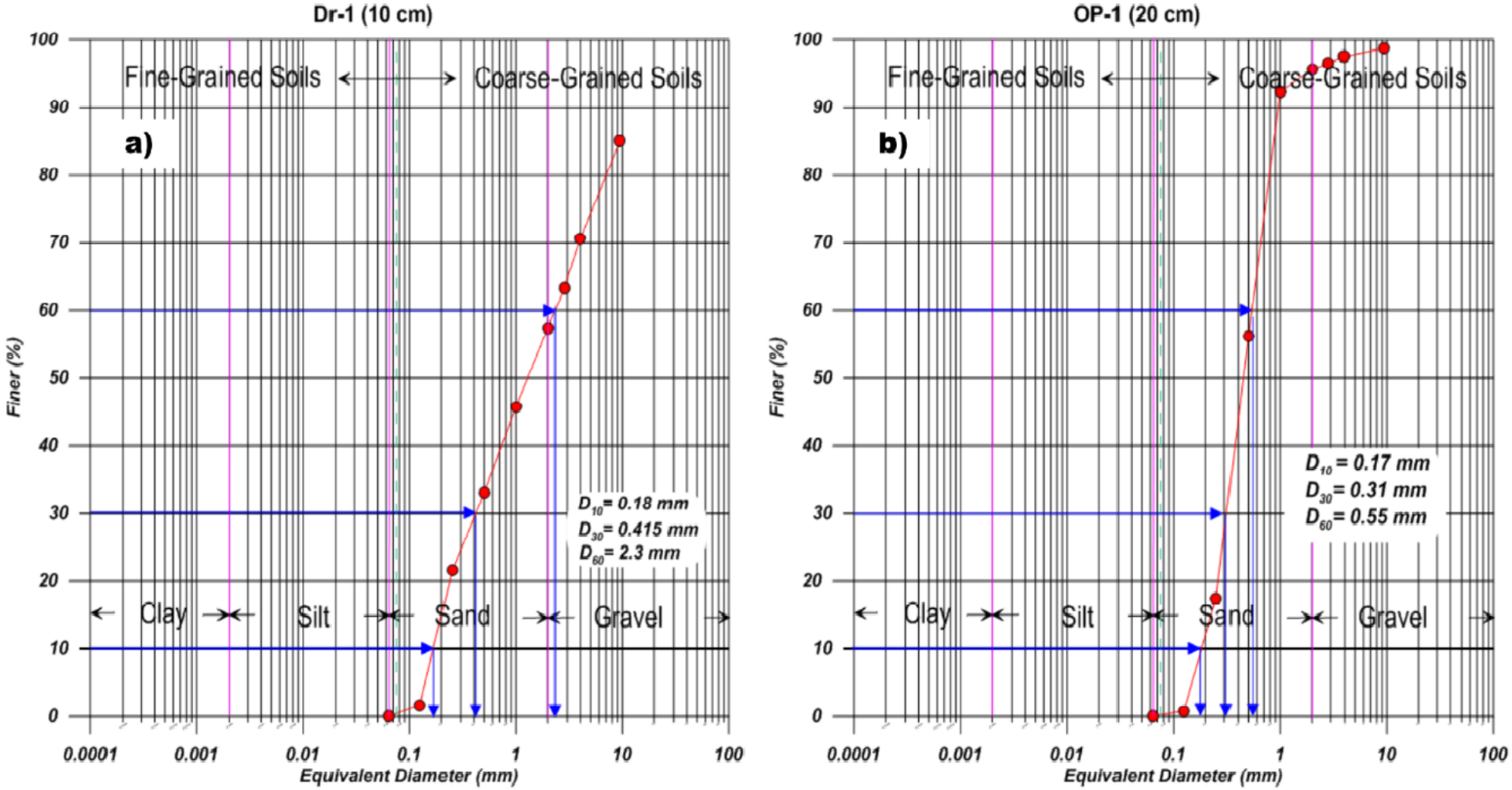


Observed infiltration rate versus time in hours for a) double ring b) open pit tests

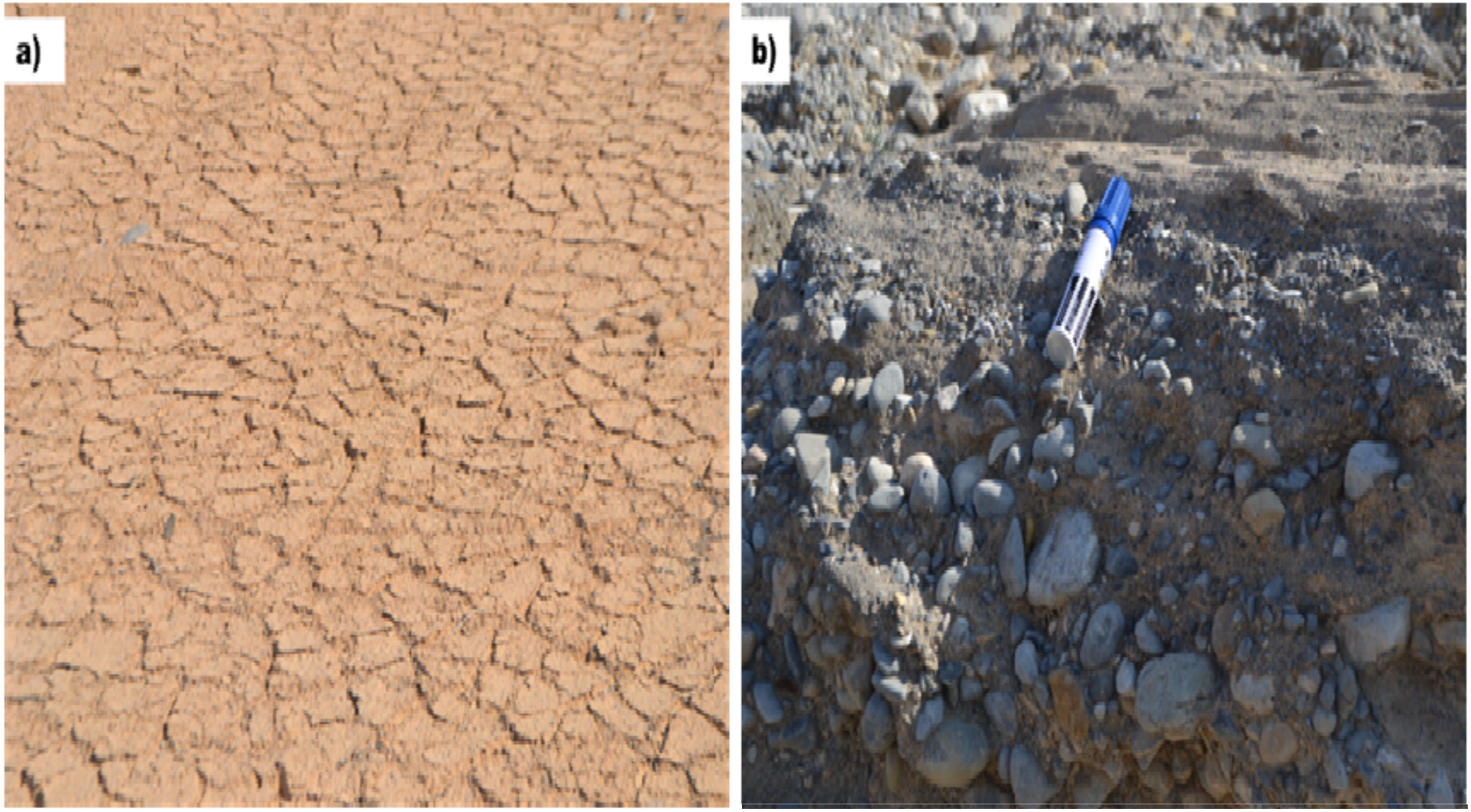
- The average values of hydraulic conductivity indicate low value (31 cm/s) at upstream site for Dr-1 and OP-2 and 3 .
- While high value (142 cm/s) are acquired at the downstream site for Dr-2 and OP-1.

Infiltration rate and hydraulic conductivity values

Location	Test ID	IR (cm/hr)	K (cm/s)
Upstream	Dr-1	3.9	11
	OP-3	2.5	74
	OP-2	23.3	7
		Average values	
		9.9	31
Downstream	Dr-2	25	277
	OP-1	67.3	6
		Average values	
		46.2	142



Sieve analysis plots a) Dr-1 b) OP-1



Soil texture variation in upstream a) nearby b) far away from the dam

Conclusions & Recommendations

- The soil texture play a vital role in the surface water infiltration However, the coarse-grained nature of the sediments and the mud cover in the dam reservoir (upstream) pushing up the water seepage in some zones and perching the water for sometimes in the other areas.

- The increase of the infiltration rate and hydraulic conductivity in the downstream site compared with the upstream site may be attributed to the coarse texture of the sediments and the dryness conditions.

- In the contrary, despite the largest reservoir area in the upstream and the coarser habit of soil textures (gravels, boulders and cobbles, etc.) the results reveal low values of infiltration rates and hydraulic conductivity parameters.

- This could be explained by the mud cover impact that decrease the hydraulic conductivity and infiltration capacity specially in the zone close to the dam .

- Accordingly, it is recommended to remove periodically the mud cover from the area closed to the upstream dam wall to make the area usually active and ready to transmit the collected rainfall water immediately to the subsurface and recharging the shallow aquifer.

- By this way, the sustainability of the shallow groundwater aquifer in the area will be preserving good water quality and big quantity to safe the water user from any sudden shortage or scarcity in the region.

Thank you for your Attention