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AGGREGATE EVALUATION, GEO-GENIC STUDIES AND ECONOMIC GEOLOGY OF EASTERN SULAIMAN RANGE, DERA GHAZI KHAN, PUNJAB, PAKISTAN

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Abstract

Geologically the research area lies in the eastern part of Koh-e-Sulaiman and administratively falls in the Dera Ghazi Khan District. The exposed stratigraphy of eastern part of Sulaiman Range (ESR) extending in age from Cretaceous to Recent along with Quaternary surficial deposits.

To evaluate the engineering properties of aggregate, three major formations (Pab Formation, Dungan Formation & Chitarwatta Formation) and the boulders/pebbles material from 10 major nalas of the field area were designated. 79 rock samples were collected for aggregate evaluation. A set of engineering test including Flakiness Index, Elongation Index, Los Angeles Abrasion, Crushing Value, Impact Value, Point Load, Specific Gravity & Absorption were performed on the rock samples as per the ASTM/BS standards. According to the engineering point of view, all the preferred rock samples fulfil the required parameters for the construction and confirm the economic values of these potential aggregate sources.

14 water samples were collected for Geo-Genic studies. The Geo-genic examination focused on the estimation of PH, Total dissolved solids, Electrical Conductivity, Resistivity, Total hardness, Calcium hardness, Magnesium hardness, Total Alkalinity, Carbonate alkalinity, Bicarbonate alkalinity, Chlorides & Sulfates of water samples. In comparison to WHO limits, the water quality of the study area is not safe.

Whereas, the economic Geology recorded upon the field observations which endorse that the field area is rich in gypsum, Silica Sand, Fuller's Earth, Dimension stones, stones for flour machine, brick making material, Raw material for cement, lime kiln and Iron.

Keywords
Aggregate Evaluation, Geo-Genic Study, Economic Geology & Dera Ghazi Khan

1. Introduction

Nowadays, with the rapid urbanization and growth in population, the construction industry is booming, and hence the demand for high-rise buildings is displaying an upward trend. This

development in building construction has led to an increase in demand for better performing building/construction materials such as high strength concrete and its components like cement, sand, and aggregates. Maintaining top quality is of utmost importance in the present times. Due to this emphasis on quality, construction has to satisfy pre-decided benchmarks and standards.

The presence of water is the signal of life and the quality of water is directly proportion to the fineness of life. In the area of investigation, the human and other living kinds consuming nala's water in everyday life. The prosperity of any area is also depends upon the presence of economic minerals. Therefore, it was decided to check the quality of stream water in accordance with the standards of WHO and the economic geology of the area.

2. Location and Accessibility

Dera Ghazi Khan abbreviated as D.G. Khan, is a city in the southern part of Punjab province of Pakistan. It is the 19th largest city of Pakistan by population. It is the headquarter of the Dera Ghazi Khan Division. The DG Khan is accessible from the Motorway M-4 and N-70 from Lahore. It lies at approximately 485 km south west from Lahore on metaled road.

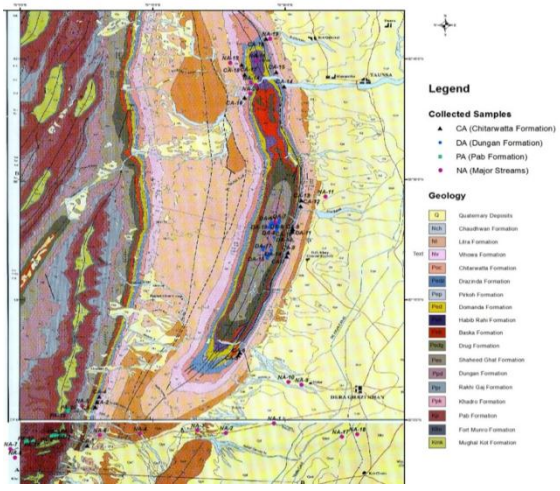


Figure1: Location map of rock & water samples (Modified after Mehmoodul Hasan et al, 2002)

3. Geology and Stratigraphy

Exposed Sedimentary rocks ranging in age from Cretaceous to Recent along with Quaternary surficial deposits were observed in the project area. The stratigraphic sequence in the study area is given in the table 1. Sedimentary rocks are limestone, sandstone, shale, marl and siltstone which are divided into Cretaceous (Mughal Kot Formation, Fort Munro Formation & Pab Formation), Paleocene (Khadro Formation, Rakhi Gaj Formation & Dungan Formation), Eocene (Kirthar & Ghazij group) Paleogene (Chitarwatta Formation), Neogene (Siwalik Group), Pleistocene (Dada Conglomerate) and Quaternary (Terrace gravel deposits, Pedimount deposits, Flood Plains & Alluvium) Mehmoodul Hasan et al., 2002; Saif Ur Rehman et al., 2019; Muhammad Naseem et al., 2003.

4. Methodology

For the evaluation of aggregate resources, three major formations (Plate.1)) and the material from 10 major Nalas i.e., Siri Nala, Rakhi Munh Nala, Mithawan Nala, Sori Nala, Dalana Nala, Sanghar Nala, Fazala Kach Nala, Zinda Pir Nala, Vidor Nala & Sakhi Sarwar Nala (Plate.3) from the field area were selected. Total 79 rock samples were collected for aggregate evaluation and their location (Late-Long) is provided in Table 2. 8 representative field samples (two from each section) were selected for lab work due to lacking of budget. All the laboratory work on collected & selected field samples were done by Geo Band Works Management and GSP Lahore office labs in Lahore. The authors are thankful to the *Geological Survey of Pakistan Lahore office & Geo Band Works Management* for providing laboratory support. Following set of engineering were performed on the rock samples as per the ASTM/BS standards.

1. Crushing Value Test
2. Los Angeles Abrasion Test
3. Impact Value Test

4. Shape Test (Flakiness & Elongation Index)
5. Specific Gravity and Water Absorption Test
6. Point Load Test

BS 812 (100-102) apply for the crushing test, ASTM C131 standard guidelines apply for the abrasion test, BS (812-112: 1990) standard procedures for the impact test, ASTM D 4791-10 standard practice apply for the shape test, ASTM C127-04 standard procedure apply for the specific gravity and water absorption test and ASTM D 5731- 95 standard guidelines apply for the Point Load test. Whereas 14 water samples were collected for Geo-genic studies. The Geo-genic examination focused on the estimation of Potential of Hydrogen, Total dissolved solids, Electrical Conductivity, Resistivity, Total hardness, Calcium hardness, Magnesium hardness, Total Alkalinity, Carbonate alkalinity, Bicarbonate alkalinity, Chlorides & Sulfates of water samples G.H. Jeffery et al., (1989).

Table 1: General Stratigraphic Succession of Eastern Sulaiman Range (Shah, S.M.I., 1991)

Era	Period	Epoch	Formation	Lithology
Cenozoic	Quaternary	Holocene	Surficial Deposits	Unconsolidated pebbles, gravels, silt & clay
		Pleistocene	Dada Conglomerate	Conglomerates
	Neogene	Unconformity		
		Pliocene	Chaudhwan Formation	Conglomerate interbedded with subordinate sandstone, siltstone/claystone
			Litra Formation	Mainly sandstone with minor claystone
			Vihowa Formation	Claystone/Siltstone intercalated with Sst.
		Disconformity		
		Oligo-Miocene	Chitarwatta Formation	Mudstone ,siltstone with sandstone beds
		Disconformity		
	Paleogene	Upper Eocene (Kirthar Group)	Drazinda Formation	Shale with subordinate siltstone, marl and Lst.
			Pirkoh Limestone	Limestone with marl and claystone
			Domanda Formation	Shale with sandstone and thin Lst. bands
			Habib Rahi Formation	Limestone with marl and shale
		Lower Eocene (Ghazij Group)	Baska Formation	Shale interbedded with limestone and gypsum
			Drug Formation	Limestone interbedded with marl and shale
			Shaheed Ghat Formation	Shale intercalated with siltstone and limestone
Cenozoic		Paleocene	Dungan Formation	Limestone with subordinate shale/marl
			Rakhi Gaj Formation	Shale, marl with sandstone and conglomerate

			Khadro Formation	Sandstone with subordinate limestone/shale
Mesozoic	Cretaceous	Unconformity		
		Late Cretaceous	Pab Formation	Sandstone with subordinate shale
			Fort Munro Formation	Limestone with subordinate shale & marl
			Mughal Kot Formtion	Mudstone intercalated with shale/limestone/marl (Base is not Exposed)

Table 2: Locations of Collected Rock Samples for Aggregate Assessment

Pab Fm.			**Dungan Fm.**		**Chitarwatta Fm.**		**10 Major Nala's**	
Sr. No.	**Longitude**	**Latitude**	**Longitude**	**Latitude**	**Longitude**	**Latitude**	**Longitude**	**Latitude**
1	70°5′4″	29°58′26″	70°29′15″	30°24′9″	70°7′38″	29°56′46″	70°28′47′	29°59′33″
2	70°4′51″	29°58′43″	70°29′2″	30°24′17″	70°8′33″	30°2′41″	70°23′20″	29°58′22″
3	70°4′45″	29°57′56″	70°28′50″	30°24′23″	70°8′44″	30°2′51″	70°20′5″	29°58′40″
4	70°4′37″	29°57′57″	70°28′39″	30°24′28″	70°9′02″	30°3′53″	70°13′34″	29°58′17″
5	70°4′34″	29°57′59″	70°28′29″	30°24′34″	70°24′56″	30°8′40″	70°7′1″	30°1′45″
6	70°4′11″	29°58′58″	70°29′19″	30°24′36″	70°24′43″	30°8′11″	70°9′1″	29°58′4″
7	70°4′2″	29°58′49″	70°29′22″	30°24′51″	70°30′14″	30°20′21″	69°58′55″	29°56′22″
8	70°3′56″	29°58′32″	70°29′5″	30°23′50″	70°30′22″	30°20′49″	69°59′25″	29°55′16″
9	70°3′48″	29°58′19″	70°29′3″	30°23′33″	70°30′52″	30°23′25″	70°30′24″	30°4′44″
10	70°3′39″	29°58′55″	70°28′48″	30°22′43″	70°30′54″	30°23′49″	70°30′24″	30°4′44″
11	70°3′33″	29°57′59″	70°28′28″	30°21′8″	70°30′54″	30°23′41″	70°34′37″	30°27′49″
12	70°1′26″	29°57′22″	70°28′17″	30°20′43″	70°31′49″	30°26′36″	70°28′59″	30°24′36″
13	70°1′34″	29°57′24″	70°28′9″	30°20′26″	70°31′55″	30°27′20″	70°26′44″	30°41′41″
14	70°0′52″	29°57′17″	70°27′57″	30°20′10″	70°29′55″	30°41′33″	70°26′10″	30°42′2″
15	70°0′36″	29°57′28″	70°27′52′	30°20′33″	70°29′3″	30°43′19″	70°23′50″	30°44′28″
16	70°0′46″	29°57′27″	70°27′40″	30°21′30″	70°25′28″	30°40′9″	70°26′52″	30°44′47″
17	70°0′37″	29°57′9″	70°27′31″	30°21′9″	70°25′27″	30°43′19″	70°38′12″	29°58′11″
18	70°5′35″	30°1′39″	70°28′19″	30°24′15″	70°25′8″	30°44′15″	70°38′12″	29°58′11″
19	70°5′23″	30°1′26″	70°28′11″	30°23′57″	70°27′54″	30°47′28″	70°28′20″	30°47′29″
20	70°5′28″	30°1′20″	70°28′32″	30°23′51″	-		70°26′6″	30°40′40″

5. Results and Discussion

It is deciphering from Table 4 that the values of Crushing test of all collected field samples varies from 3.8 to 5.88 % which shows strong results. The associated values of aggregates regarding crushing test, if it is 10 % < Strong aggregate, 11-30 % = Normal aggregate, 35 % > Weak aggregate and in some cases it may be permitted up to 45%. The Los Angeles Abrasion test of all composed field sections fluctuates from 20.3 to 21.9 % which displays durable consequences. It is recommended that abrasion value of aggregate should not be more than 30 % for aggregate used for surface wearing course and, should not be more than 45 % for surface other than wearing course.

The outcomes of Impact Value test of collected field divisions oscillate from 7.4 to 10.74 %

which demonstrates long-lasting values. Aggregate impact value is the same as the abrasion test result. Impact value of aggregate should not exceed 30 percent for aggregate used for surface wearing course and should not exceed 45 percent for surface other than wearing course, the conclusions of Shape Value test of collected field samples vary from 7.23 to 14.94 % which validates for enduring standards. Recommended result of shape test of aggregates should be in range of 15% to 30% according to the area of use.

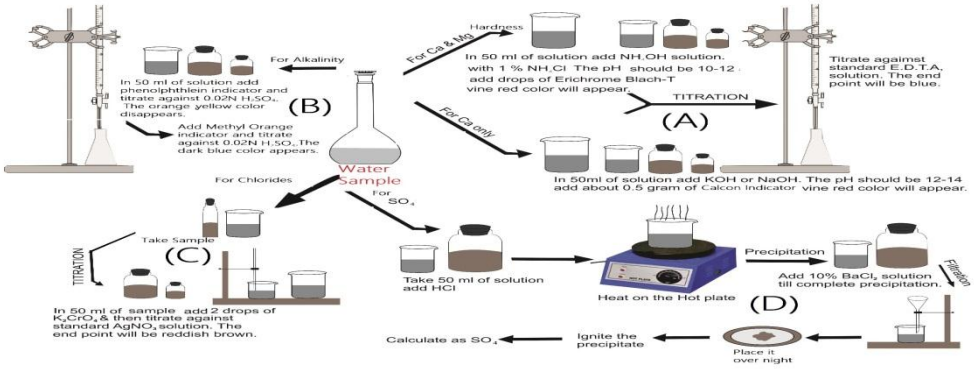


Figure 2: Four Steps Chemical Analysis For Water

A: Estimation of Hardness by titration against EDTA, B: Estimation of Alkalinity by titration against H_2SO_4, C: Estimation of Chlorides by titration against $AgNO_3$ and D: Estimation of Sulfates by gravimetric method using $BaCl_2$

Table 3: Laboratory Analysis For Aggregate Evaluation

Sr. No.	Formation	ID	FI %	EI %	LAA %	SG	WA%	CV%	IV %	PL Mpa
1	Chitarwatta Formation	S-1	8.32	13.35	21.8	2.65	0.64	5.83	10.65	65
		S-2	8.65	14.94	21.3	2.64	0.66	5.88	10.74	63.5
2	Pab Formation	S-1	7.69	8.56	21.6	2.65	0.64	5.79	9.89	120
		S-2	7.14	8.26	21.9	2.66	0.65	5.66	9.72	112
3	Dungan Formation	S-1	14.62	7.23	21.9	2.67	0.58	3.8	7.65	55
		S-2	14.29	7.65	21.2	2.65	0.54	4.1	7.4	59
4	Major Nala's Material	S-1	8.69	11.87	20.36	2.63	0.62	4.89	8.44	80
		S-2	8.46	12.68	20.8	2.64	0.65	4.7	8.2	76
Average Specifications			Less than 35%		Less than 35%	2 to 3	Less than 2%	Less than 30%	Less than 27%	78

Whereas: ID = Sample identification, FI = Flakiness Index, EI = Elongation Index, LAA = Los Angeles Abrasion, SG = Specific Gravity, WA = Water Absorption, CV = Crushing Value, IV = Impact Value and PL = Point Load.

Note: Each result is the average of five samples in all tables 3, 4 & 5.

The conclusions of Specific Gravity and Water Absorption Test of collected field samples varies from 2.63 to 2.67 % and 0.54 to 0.66 respectively. The specific gravity of aggregates generally used in construction ranges from about 2.5 to 3.0 and water absorption ranges from about 0.1 % to 2.0 %, The interpretations of Point Load Test of whole field samples for lab testing differs from 55 to 120 Mpa, which also verifies for durable benchmarks. Hence, it is concluded from the above results that the selected three formations and the boulders, pebbles & conglomerates material from 10 major Nalas are approved for the quarry site regarding aggregate.

Table 4: Physical Parameters of Water Samples

Sample ID	Area/Locality	PH	TDS	EC	Resistivity
1	Zabra/Satta,	6	11593	23.66	0
2	Mithawan Nala	5	3391	6.92	0.0001
3	Sori Nala	7	10297	21.01	0
4	Fort Munro Dam	7	520	1.062	0.0009
5	Fort Munro Pound	7	1708	3.49	0.0003
6	Vidor Nala	7	5794	11.82	0.0001
7	Qadka Top	7	1119	2.284	0.0004
8	Siri Nala	6	1779	3.63	0.0003
9	Rakhi Nala	7	3654	7.46	0.0001
10	Rodho Top	7	7227	199.8	0
11	Sangar Nala	6	3665	7.48	0.0001
12	Moza Piagah	6	3471	7.08	0.0001
13	Zindapir Chashma	10	14735	30.1	0
14	Ghulki Area	6	6856	13.99	0.0001

As table 4 shows the PH of seven samples is within permissible limit and other seven including Zabra/Satta, Mithawan Nala, Siri Nala, Sangar Nala, Moza Piagah, Zindapir Chashma, and Ghulki area have crossed the permissible range. Whereas, all water samples were found colorless and odorless. TDS and electrical conductivity of all samples is beyond permissible range. However, the resistivity of all samples is within range. WHO drinking water limit for pH is 6.5-8.5, for TDS it is 500ppm and for conductivity it is 0.4 mS/cm (D. O. Okorie et al., 2015). Whereas, Pakistan Agricultural limit for pH is 6.5-8.4, for TDS it is 1000 ppm and for conductivity it is 0.25 mS/cm. M. Amir khattak et al., (2012). Note: PH is measured on scale 1 to 14 by PH paper, TDS is measured in parts per million, EC is measured in milli-Siemen per centimeter & Resistivity in mega ohm centimeter.

It is evident from table 5 that the highest concentration of Hardness was observed in sample from Rodho Top while lowest in Zindapir Chashma. Out of these fourteen samples, five found as hard water with respect to both Calcium and Magnesium. Three samples found as hard water with respect to Calcium and ten found as hard water with respect to Magnesium. The most alkaline water among the samples is Zindapir Chashma and least alkaline is Sangar Nala. Eight samples cross the safe limit of water with respect to Bicarbonate alkalinity. Three samples having higher concentration of Chlorides above recommended limit. Rodho Top shows highest concentration of chlorides and Fort Munro Dam shows lowest. Only one sample exceeded the recommended limit of sulfates. i.e., Rodho Top. Lowest percentage of sulfates was observed in Qadka Top. Hence, in general, the water quality of the study area is not safe for drinking purposes.

Table 5: Chemical Parameters of Water Samples

Sample ID	Total Hardness	Ca-hardness	Mg-Hardness	Ca ions	Mg ions	Total Alkalinity	CO_3 Alkalinity	HCO_3 Alkalinity	Chlorides	SO_4 ppm
1	1470	720	750	28.8	180	370	20	350	536.05	129.8624
2	455	90	365	3.6	87.6	430	80	350	184.6	47.2976
3	355	80	275	3.2	66	630	120	510	1238.95	57.9272
4	155	60	95	2.4	22.8	250	40	210	28.4	40.7056
5	85	15	70	0.6	16.8	900	180	720	159.75	36.668
6	655	145	510	5.8	122.4	470	60	410	159.75	23.7312
7	35	15	20	0.6	4.8	500	60	440	49.7	10.2176
8	275	55	220	2.2	52.8	435	70	365	42.6	43.672
9	580	125	455	5	109.2	390	60	330	56.8	118.5736
10	10300	205	10095	8.2	2422.8	1050	180	870	4274.2	1959.06
11	375	140	235	5.6	56.4	250	80	170	74.55	133.488
12	455	110	345	4.4	82.8	470	40	430	142	110.416
13	40	5	35	0.2	8.4	5470	1140	4330	1207	31.724
14	795	425	370	17	88.8	330	60	270	223.65	168.5904

6. Conclusion & Recommendations

It is obvious from the laboratories analysis of rock samples for aggregate evaluations that the results fall within the required range as per specifications. Shape test less than 35%, Los Angeles Abrasion less than 35%, Specific Gravity 2 to 3, Water Absorption less than 2 %, Crushing Values less than 30%, Impact Value less than 27 % and the mean value of Point Load Test is 78 Mpa. Hence, it is concluded that the selected three formations and the material from 10 major Nalas is accepted for the quarry site regarding aggregate (Table 3).

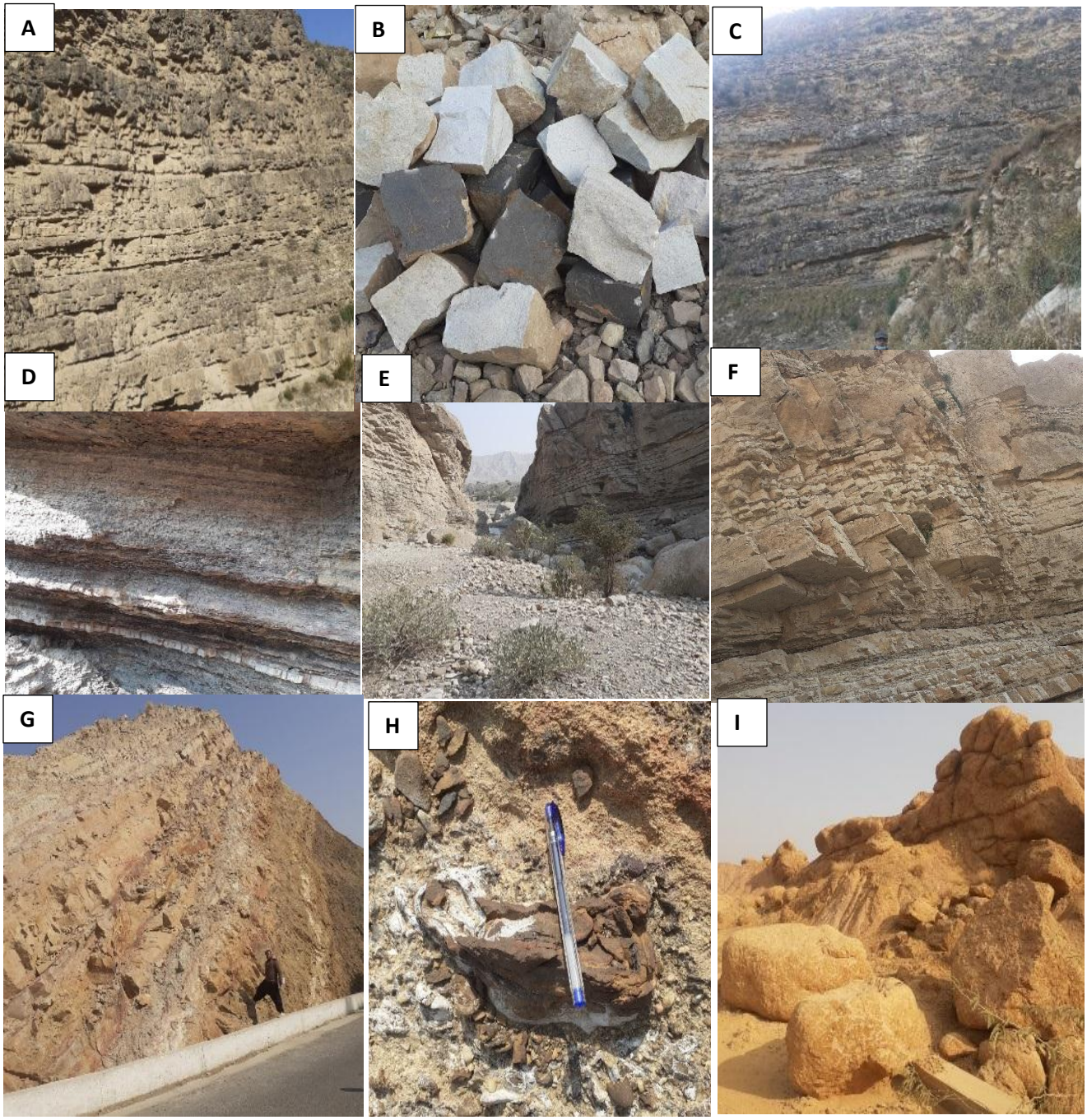
In comparison to WHO limits, the water quality of the study area is not safe for drinking and agriculture purposes (Table 4 & 5).

Field observation confirms that the project area is rich in gypsum, Silica Sand, Fuller's Earth, Dimension gravels, brick making material, material for cement, stones for flour machine lime kiln and Iron (Table.2). The above mentioned industries should be constructed for the prosperity of the area after the profound research of individual entities.

As CPEC route also passing near the project area so it has great importance regarding Limestone and Sandstone that is present in huge quantity. These reserves may be used as aggregate for construction purposes. Sandstone is typically used as flooring or paving materials.

The range is also lies in the monsoon region, so small dams may also be constructed to save water as well as the region holds some ideal places where Tourism Development Corporation of Pakistan (TDCP) may develop pleasurable dwellings which can generate profits for the state.

Plate 1: Field Photographs of Selected Three Major Formations

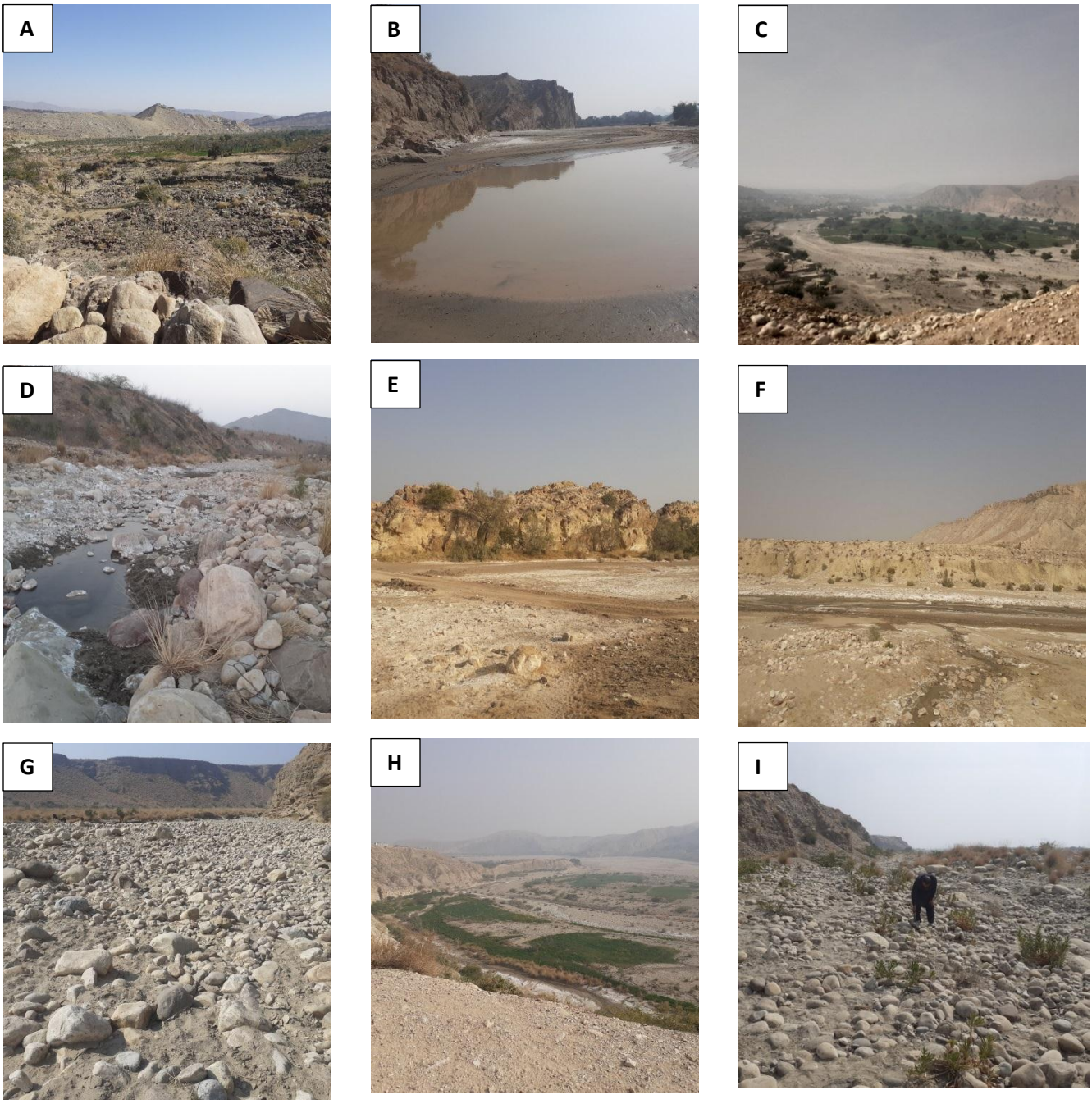


Whereas: A, B &C = Pab Formation, D, E & F = Dungan Formation & G, H & I = Chitarwatta Formation.

Plate 2: Field Snaps Of Observed Economic Geology Of The Area

Whereas: A = Silica Sand, B = Stone for flour machine, C = Fuller's Earth, D = Lime Kiln, E = Dimension Stone, F = Bricks, G = Iron nodule, H = Site for small dam & I = Natural mountain honey.

Plate 3: Field Pictures Of Major Nala's Of The Area



Whereas: A = Siri Nala, B = Sori Nala, C = Fazla Kach Nala, D = Rakhi Munh Nala, E = Sakhi Sarwar Nala, F = Mithawan Nala, G = Vidor Nala, H = Sanghar Nala & I = Dalana Nala.

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