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# Reletionship Between the Physico-Chemical Properties and Different Types of Erosion on Marl Soils South of Tehran, Iran

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Marls in arid lands are greatly erodable regions originating sediment in these lands. These type of soils are found in many part of Iran and also in several colors like gray, red and green. Erosion process in marls in lack of plant cover decreasing permeability is very active specially in marl dunes and different types of erosion specially badland is one of the distinctive properties in marl regions and there are many main and complex factors in marls erosion. The erosion in marls also depends on environmental factors like rain distribution and soil properties. The importance of marls is in type and amount of sediment that is produced and the variety of erosion forms. According to mentioned factor now-a-days effective longevity of huge dams in Iran such as Sefidroud, Save and Panozdahe khordad have been decreased and be continuously interesting for most of specialists and researchers for earth science. The study of erosion forms in marls demonstrated a direct relationship between erosion forms and some soil chemical properties and includes different sort of erosion such as sheet erosion, rill erosion and badland and the most density of rill and galley is on the marls that have high solution sodium and sodium absorption ratio (SAR). The comparing of mean physico-chemical factors of marls with different erosion forms demonstrated that the amount of Na, Mg, SAR, pH and organic carbon have significant difference in sheet, rill and badland erosion. This problem account for the role of above factors in stable and unstable of region marl and among that factors SAR value is the most important in marls that controls erosion index. The occurence of many causes of slope instability in marls formation in these regions of Iran on the one hand and lack of comprehensive research on this topic on the other hand, formed the main incentive to carry out the present paper.

**Key Words: Marl soils, Badland, Sheet and rill erosion, SAR.**

## INTRODUCTION

Marls in arid climates are areas with a high degree of credibility and the source of producing sediments. Erosion processes in marls are too active, because of negible amount of permeability without vegetation cover, specially marl hills. However, different forms of erosion particulary badlands are some characteristics of marl fields[1].

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Erosion causing factors in marls, are numerous and include complex process, so that erosion in marls depend on external factors (such the distribution of precipitation) and internal factors (such soil properties). On the basis of last studies it is found that compounds such organic matter, ferro and aluminum oxides, make marls durable, while sodium ions cause more erosion with diffusing clay particles. So the ratio of exchangable sodium in marls can be a good index of diffusion. By means, in areas which chemiophysical properties of geological formations are the most important factors in determining the erosion forms, hydrological alternatives, have less importance in erosion[2].

There are many laboratory researches on the effect of chemico-physical properties on the erosion susceptibility of geological formations and soil. But there is a few field experience about. At the present paper, it is essayed to examine the marl areas of south of Tehran, with semi arid climate and the results of their chemico-physical effects are to be offered.

## EXPERIMENTAL

The marl fields of south of Tehran with area about 65,000 hectars. The most important of geological formations of this area are Kertase, inferior red and specially Qom. The studied area has semi arid climate an the means of its maximum and minimum temprature are 35.7 and -6.0 °C, respectively. Mean annual temprature is 14.1 °C, the length of frost period is three months and the mean of annual precipitation is 295 mm. At this region the highest precipitation is pertainig to February, March, April and May. Vegetation cover at the steep slopes is worthless, so that the vegetation cover in some slope in existence, has a sparse distribution and includes *Ayuga chamneositms*, *Stipa* sp., *Gypsaphylla viygatta*, *Salsola* sp. It must be said that in the field of study, marls are seen as hills and high grounds. At some areas, also marl fields are plain ship fields, because of severe erosion.

After field separation, different forms of erosion, include sheet erosion, rill erosion and badland, took sampled form surface layer (0-15 cm) in the case of sheet and rill erosion and deeper layer for badland and then chemico-physical alternatives of soils such EC, pH in saturated mud, rate of $CaCO_3$, gypsum, organic carbon, soluble sodium ions, Mg, $CaSO_4^{2-}$, $HCO_3^-$, CEC, sand, clay and SAR were measured in laboratory.

Since the samples were form three state of erosion (and in each state 22 samples), so for determining of the most important chemico-physical factors, test of comparing the mean of small samples with t-student test at the levels of 0.1, 0.05 and 0.01 was done. Then result of test was determine with calculating t and considering the degree of freedom and confidence level and with help of t-table. Considering that in this research, interaction of chemical and physical factors in each farm of erosion had great importance, thus for gaining final results, the examining of statistical analysis of comparing sample mean test was used.

The studied marls are also sabotage-chemical rocks that their major parts are $CO_3^{2-}$ and clay parts (35-65 %). The condition of farming marls are so that their spatial and temporal distributionare numerous[3].

Nowadays, a wide field of marls in France, Spain, Iran and other countries specially from the period of kartace are known up now, that their major disturbance is related to third are means after aosen. The studied area marls are divided into 3 groups from the aspect of geological age: (i) Marl of kertace formation that is in alteration with lime and sand lime that has thin layering and mostly light green to brown. (ii) Marl of lower red formation that is in alteration with red marl, sandy marl, sand stone and granuled congolomera and is grayish to red. (iii) Marl of Qom formation that is in alteration with thin layered lime, silt stone and granuled sand stone and is light gray[4].

## RESULTS AND DISCUSSION

### Chemico-physical properties of marl

**EC:** Mean rates of EC for marls with Sheet erosion to bad land are between 1.2-3.3 mm $cm^{-1}$, so that the increasing trend from sheet erosion to rill rosion and then badland is observed (Table-1). In addition, comparison of mean rates of sheet erosion (S), rill (R) and badland (B) with t- test, implies the significant difference[5] at the 0.1 and 0.5 levels (Table-2).

TABLE-1
MAX, MEAN AND MIN VALUES OF CHEMICAL AND PHYSICAL VARIABLES IN DIFFERENT TYPES OF EROSION

| Erosion types Variables | Badland erosion | | | Rill erosion | | | Sheet erosion | | |
|---|---|---|---|---|---|---|---|---|---|
| | Min. | Mean | Max. | Min. | Mean | Max. | Min. | Mean | Max. |
| $EC \times 10^3$ | 0.062 | 3.28 | 10.96 | 0.118 | 1.79 | 6.28 | 0.01 | 1.21 | 3.1 |
| pH | 7.3 | 8.18 | 8.7 | 7.6 | 8.06 | 8.7 | 7.9 | 8.03 | 8.3 |
| $CaCO_3$ | 14 | 39.27 | 80 | 37 | 43.18 | 50 | 25 | 40.42 | 56 |
| $Na_2SO_4$ | 0.7 | 2.15 | 4.9 | 0.5 | 1.91 | 4.3 | 0.5 | 1.79 | 5.5 |
| $Na^+$ | 190 | 324.64 | 930 | 42.5 | 88.77 | 165 | 3 | 10.11 | 30 |
| $Mg^{2+}$ | 0.1 | 3 | 13 | 1.2 | 2.18 | 12 | 0.1 | 0.94 | 3 |
| $Ca^{2+}$ | 1 | 9.11 | 45 | 0.5 | 9.47 | 41.5 | 1 | 7.14 | 19 |
| $Cr^{3+}$ | 1.5 | 19.35 | 80 | 1 | 7.45 | 35 | 2 | 4.59 | 13 |
| $SO_4^{2-}$ | 1.2 | 5.68 | 11 | 5 | 24.23 | 88 | 1 | 7.35 | 15 |
| $HCO_3^-$ | 1 | 3.75 | 13 | 1 | 6.39 | 55 | 1.5 | 4.24 | 16 |
| CEC | 3 | 11.42 | 24 | 4 | 7.43 | 21 | 3.8 | 6.22 | 8 |
| SAR | 42.2 | 19.07 | 346.7 | 9.5 | 69.3 | 222 | 0.9 | 7.03 | 29.4 |
| Clay (%) | 17 | 31.14 | 45 | 22 | 32.18 | 42 | 15 | 29.14 | 42 |
| Silt (%) | 30 | 40.41 | 56 | 25 | 37.5 | 52 | 29 | 40.5 | 54 |
| Sand % | 14 | 28.41 | 42 | 8 | 29.86 | 42 | 16 | 30.82 | 44 |
| Org (%) | 0.68 | 1.81 | 2.8 | 1.45 | 2.3 | 2.9 | 1.5 | 2.35 | 3 |

TABLE-2
EVALUATING OF MEAN COMPARISON TEST OF CHEMICOPHYSICAL VARIABLES IN DIFFERENT TYPES OF EROSION; SHEET EROSION (S), RILL EROSION (R) AND BADLAND (B) EROSION; (+) SIGNIFICANT (–) NON-SIGNIFICANT

| Soil variables | Erosion comparisions | t value | Probably | | |
|---|---|---|---|---|---|
| | | | 0.1 | 0.05 | 0.01 |
| EC | R and S | 1.318 | + | – | – |
| | B and R | 2.170 | + | + | – |
| | S and B | 30.200 | + | + | + |
| pH | R and S | 0.415 | – | – | – |
| | B and R | 3.470 | + | + | + |
| | S and B | 1.800 | + | + | – |
| $CaCO_3$ | R and S | 1.020 | – | – | – |
| | B and R | 1.040 | – | – | – |
| | S and B | 0.370 | – | – | – |
| $CaSO_4$ | R and S | 0.319 | – | – | – |
| | B and R | 0.650 | – | – | – |
| | S and B | 2.010 | – | – | – |
| Organic carbon | R and S | 0.420 | – | – | – |
| | B and R | 2.700 | + | + | + |
| | S and B | 3.090 | + | + | + |
| $Na^+$ | R and S | 10.220 | + | + | + |
| | B and R | 6.150 | + | + | + |
| | S and B | 8.180 | + | + | + |
| $Mg^{2+}$ | R and S | 1.790 | + | + | – |
| | B and R | 0.790 | – | – | – |
| | S and B | 2.580 | + | + | + |
| $Ca^{2+}$ | R and S" | 0.620 | – | – | – |
| | B and R | 0.100 | – | – | – |
| | S and B | 0.600 | – | – | – |
| $Cr^{3+}$ | R and S | 1.490 | + | – | – |
| | B and R | 2.540 | + | + | + |
| | S and B | 3.390 | + | + | + |
| $SO_4^{2-}$ | R and S | 2.670 | + | + | + |
| | B and R | 2.980 | + | + | + |
| | S and B | 1.560 | + | – | – |
| $HCO_3^-$ | R and S | 0.850 | – | – | – |
| | B and R | 1.040 | – | – | – |
| | S and B | 0.460 | – | – | – |
| CEC | R and S | 1.270 | – | – | – |
| | B and R | 0.520 | – | – | – |
| | S and B | 3.320 | + | + | + |
| SAR | R and S | 5.830 | + | + | + |
| | B and R | 5.730 | + | + | + |
| | S and B | 9.950 | + | + | + |
| Clay (%) | R and S | 1.440 | + | – | – |
| | B and R | 0.510 | – | – | – |
| | S and B | 0.910 | – | – | – |
| Silt (%) | R and S | 1.430 | + | – | – |
| | B and R | 1.190 | – | – | – |
| | S and B | 0.150 | – | – | – |
| Sand (%) | R and S | 0.360 | – | – | – |
| | B and R | 0.530 | – | – | – |
| | S and B | 0.540 | – | – | – |

**pH:** All samples of different forms of erosion have pH > 7.5. At the different levels of confidence there was no significant difference between the pH of marls with sheet and rill erosions. But there was significant difference at confidence levels of 0.1, 0.05 and 0.01, between the sample of rill erosion and badland associated with sheet erosion (Table-2).

In addition, with regard to Table-1, from the trend of pH increase from sheet erosion to badland, it can be concluded that high acidity implies its effect on the increase of severness and type of erosion, specialy badland.

**Calcium carbonate and gypsum:** Table-1 showed that the mean amount of $CO_3^{2-}$ and gypsum in all samples are 39-42 % and 1.9-2.9 cmol kg$^{-1}$ soil, raspectively. The maximum $CO_3^{2-}$ amounnt (80 %) is pertaining to marls with badland erosion and maximum gypsum (505 cmol kg$^{-1}$) is pertaining to marls with effective elastic thickness (EET) erosion. Statically examining expresses that, there is no significant difference between mentioned alternatives with different forms of erosion. Thus, it is not possible to choose $CO_3^{2-}$ and gypsum rate as an index for determining erosion forms[7].

**Organic carbon:** Mean percentage of organic carbon of marls is between 1.8-2.35, so that the minimum rate is 0.67 related to marl with badland and the maximum rate is 3 % relate to marl with sheet erosion (Table-1). In addition, with comparison of the means of organic carbon at different forms of erosion, it was determined that there is no significant difference between marls with sheet and rill erosion at different level (Table-2). While, this difference is significant between sheet erosion associated with badland and rill erosion associated with badland. It must be said that the trend of decreasing organic carbon from sheet erosion to badland is considerable. Therefore, the excess amount of organic carbon can be viewed as the other index for separating erosion forms in marls[8].

**Cations:** The most important cations of the marls of this area include $Na^+$, $Mg^{2+}$ and $Ca^{2+}$. On the average the concentration of $Na^+$ is between 10-325, $Mg^{2+}$ 1-3 and $Ca^{2+}$ is between 7-9 cmol L$^{-1}$. Maximum rate of $Na^+$, $Mg^{2+}$ and $Ca^{2+}$ are 930, 11 and 45 cmol L$^{-1}$, pertain to marls with badland (Table-1). Comparison of $Na^+$ and $Mg^{2+}$ cations in marls with different forms of erosion shows the significant difference at different levels of confidence. But this significant difference is not shown in $Ca^{2+}$ (Table-2). Thus, $Mg^{2+}$ and specially $Na^+$ included in marl, are the most important factor in marls durability, because high percentage of $Na^+$ lead to increase in soil particles diffusion, that itself contribute in the adverse from of erosion[9].

**Anions:** The most important anions of the marls of this area include $SO_4^{2-}$, $Cl^-$ and $HCO_3^-$ that show a wide spectrum in erosion forms (Table-1), so that in different forms of erosion the significant difference between $SO_4^{2-}$ and $Cl^-$ at different levels is obvious. While, this significant difference is not shown in $HCO_3^-$.

In addition, there is not a significant difference in $SO_4^{2-}$ between sheet erosion and badlands, in 0.05 and 0.01 level and also in $Cl^-$, between sheet and rill erosion in mentioned levels.Totally, increase in $Cl^-$ can contribute to compounds associated with Na and Mg lead to in durability and credibility of marl[10].

**CEC and SAR:** The mean CEC of marl in this area was 6-11, so that its minimum rate 8 cmpl $L^{-1}$, relates to Sheet erosion and its maximum rate 24, relates to marls with badland (Table-1). In addition SAR is 7-190 that its minimum 0.9 in marls with sheet erosion and its maximum 346.7 relates to the marls with badland. It must be said that comparison between means of CEC in marls with sheet erosion associated with rill erosion and rill erosion associated with badland, did not show a significant difference at different levels. This difference is significant between sheet erosions with badland (Table-2). SAR rate also, show significant difference at the 0.1, 0.05 and 0.01 levels. So, SAR can be one of the most important alternatives, in controlling indurability and erosion severeness at the marls of this area[11].

**Soil texture:** The contents of clay, silt and sand at the marls of this area have a stable proportion, so it has not been observed any significant difference between different type of erosion at all levels, then it can be concluded that the particles of soil have no role in the stability of the marl of the area.

**Type of erosion**

**Sheet erosion:** The dominant form of erosion in this area is sheet erosion. This type of erosion is observed from uncoating of shrub stands, sparseness of vegetation cover. Chemical analysis of soils under sheet erosion shows calcium carbonate equal 40.42 %. The rate of organic carbon in similar samples was 2.35 %, gypsum 1.79 cmol $kg^{-1}$ soil, pH of saturated mud 8.03 and finally the rate of SAR was less than 10 and its solved sodium was more than 10 cmol $L^{-1}$. With use of the proportion of sodium absorption and total concentration of cations in the saturated extract of soil, the marls under the effect of sheet erosion are located at an undiffused region and, mediator that shows low diffusive of marl particles, so the marl under the effect of sheet erosion can be found as marls which concentration of solved sodium ion in them is low and solved salts have mediate rate and also amount of SAR is low[12].

**Rill erosion:** The surface horizon of the soil under the effect of rill erosion has granules texture with microscopic to macroscopic rills[12]. The rate of organic carbon in such field is 2.3 %, calcium carbonate 42.18 % and pH 7.6-8.7. At the surface horizons of soil, CEC is 7.43 % cmol $L^{-1}$. SDR is 69.3 and sodium concentration is more than 8.8 cmol $L^{-1}$.

**Badland erosion:** Some charactristics of badland include granuled texture soil unpremiable and condenced ditch, which gypsum rate here is relatevely more inproportion with sheet and rill erosion (2 cmol $kg^{-1}$ soil).

In addition the percentage of organic carbon in the soil under the effect of badlands, is equal with 1.81 with the acidity of 7.3-8.7 in such fields CEC is 11.42 and the rate of SAR is more than 190, while the proportion of clay, silt and sand (%) in comparision to the sample of sheet and rill erosion, do not show much change (Table-1). In regard to the rate of absorbable sodium and total concentration of solved cation, the diffusion index at the field under the effects of badlands are located at diffusion region that implies the hollowness of marls. Beniter *et al.*[1] believed that the badland take places in high levels of solved sodium. SAR 40 and mediate rate of salts.

## Conclusion

Sheet erosion is the most important form of erosion in this area. While severeness of this type of erosion is less than other type of erosion (rill, badland) but at the deffusive marl of this area ditch and rill erosion are observable whit high condensation that the severeness of erosion in them are too high field examinations imply existence of badland field in marls whit sodium and high concentration of total cations. So, because of role of sodium in calculating SAR, then some marls of this area with high-solved sodium ion and SAR, has a high index of diffusion. With analyzing and comparing means, it seems that, in addition to solved sodium and SAR, factors such salinity, Cl, pH and Mg make badland more probable, because of making limitation in growing vegetation. While calcium carbonate, gypsum, $Ca^{2+}$, $HCO_3^-$, clay, silt and sand, have not important effect in form and type of erosion. But high percentage of organic carbon in marl under the effect of sheet erosion, in proportion with fields under badland, implies the role of organic carbon in increasing the stability of marls. Then, it can be concluded that sodium ion, SAR and the rate of organic carbon, can be figured out as important indices in separating erosion forms in marls, but to obtain more certain results, it is necessary to perform similar research in the other regions of country.

**Recommendation:** With regard to the results of this research, inspite of relatively high sensivity of water erosion at this area, it can be emphasized on correct exploitation with enhancing its quality. So, the following general recommendation as the principle of correct exploitation. In parallel with conserving and exploitating of the land at this area, are offered. (i) regard to graze controls as one of the most important ways in controlling erosion and help to reclamation of this area. (ii) Preventing from changing steep range land to dry farming.

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