Determination of adsorption behaviour of selected rock samples for Cu^{2+}, Mno_4^- and $Cr_2O_7^{2-}$ from their aqueous solutions by using UV-VIS Spectrophotometer

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Abstract: *The objective of this research is to investigate different rock samples on their adsorption abilities of specific ions viz. Cu^{2+}, $Cr_2O_7^{2-}$ and MnO_4^-. Selection of different rocks was made in a specified area of Mizoram state in India. The color of rock samples ranges from brick-red to grey and these are the most common rocks found in that particular area. Their hardness varies with colors from rock to rock which is in the order: Grey(S-I) > Light grey (S-II) > Chesnut brown(S-IV) > Brown (S-III)> Light brown (S-V) > Brick red (S-VI). Powder of different rocks were tested for their adsorption abilities toward ions from known concentration of solutions like Potassium permanganate that dissociates in water to give K^+ ion and MnO_4^- ion, Potassium dichromate which dissociates in water as $2K^+$ and $Cr_2O_7^{2-}$ and Copper Sulfate that dissociates in water as Cu^{2+} and SO_4^{2-}. The color of these solutions are owing to the presence of Cu^{2+}, MnO_4^- and $Cr_2O_7^{2-}$respectively. The extent of adsorption on powder of different rocks were estimated by using UV-VIS spectrophotometer. The change in concentration of solutions before and after mixing with rock powder determines the magnitude of adsorption on different specimens of rock. λ_{Max} was determined for each solution and the degree of adsorption on different rocks were determined at that particular wavelength.*

Key Words: *Adsorption, absorbance, chemical and physical properties, concentration, UV-VIS spectrophotometer, wavelength, λ_{max}*

1. INTRODUCTION:

Adsorption is an important property of some solids, where adsorbate are adsorbed on the surface of adsorbent, depending upon the strength of bond between adsorbate and adsorbent it is classified into physical adsorption and chemical adsorption. The phenomenon of adsorption is widely used in environmental issues for removing toxic chemicals in air and water. The degree of adsorption on different solid materials and their adsorption abilities for a particular species varies from substance to substance. The extent of adsorption on a given surface area increases with concentration of adsorbate.

Not all rocks are same in compositions and structures, so that, their colors, hardness, permeabilities etc. are also different. Adsorption abilities of many solids depends upon surface area of adsorbent which further depends upon the number of pores and pore size. The size of pore governs adsorption for a specific adsorbate. Rocks are available everywhere in our surroundings, they are expected to have such an adsorption capacities for some solute and that is why we are interested in the analysis of various kinds of rock for their adsorption behaviour. The color of compounds containing metals are mainly due to electron movements within a compound that leads to an absorption and emission in visible region. This is perhaps the result of charge transfer from ligand to metal, metal to ligand, d-d transition etc. According to Beer's law, absorption of light depends upon the concentration of solution; more the concentration of a solution more will be its absorbance at a particular wavelength. This property is very useful for measuring the concentration of unknown solution by knowing the absorbance of a known solution.

2. METHODOLOGY:

2.1 Preparation of sets of samples

Firstly, three sets of rock powder were prepared. Each set comprises six different rock powder namely, S-I, S-II, S-II, S-IV, S-V, S-VI. The first set of rock powder would be mixed with $CuSO_4.6H_2O$ solution (OS-II(CS)) they were represented as S-I(CS), S-II(CS), S-II(CS), S-IV(CS), S-V(CS), S-VI(CS) respectively. In the second set, solution of $K_2Cr_2O_7$ (OS-II(P)) would be added, the set consists of S-I(P), S-II(P), S-II(P), S-IV(P), S-V(P), S-VI(P) and in the third set $KMnO_4$ solution (OS-II(KM)) would be added and the third set would contain S-I(KM), S-II(KM), S-II(KM), S-IV(KM), S-V(KM), S-VI(KM). Then, Solution of known concentration for each compound wound be prepared viz. OS-I (CS), OS-II (CS), OS-I(P), OS-II(P), OS-I (KM) AND OS-II (KM) respectively. The concentration of OS-I solutions are higher than those of OS-II solutions.

2.2. Experimental procedure

Solution of potassium dichromate with strength; 0.025 M [OS-I (P)], 0.00652 M [OS-II(P)] and potassium permangate; 0.0025 M [OS-I(KM)], 0.000652 M [OS-II(KM)] and copper sulfate; 0.05 M [OS-I (CS)], 0.025 [OS-II(CS)] were prepared. The least concentrated solutions viz. OS-II(P), OS-II(KM) AND OS-II(CS) were taken as the original sampling solutions for the experiments and λ_{max} was determined for each solution . Rock of different types (Six types) were collected in a specified area i.e. Zotlang village, Champhai district, Mizoram state in India and they were grinded to power. The pH of each rock samples was measured by using pH meter (Sample of rock powder and water was mixed in the ratio 1:1 and pH was measured for each sample). Equal amount of each rock powder was taken in a separated containers and were represented as S-I, S-II, S-III, S-IV, S-V, S-VI respectively. In one set of rock powder equal quantity of copper sulfate solution with equal strength (0.025 M) were mixed denoted by S-I(CS), S-II(CS), S-II(CS), S-IV(CS), S-V(CS), S-VI(CS). Similarly the second set of rock powder were mixed with equal quantity of 0.00652 M potassium dichromate solution viz. S-I(P), S-II(P), S-II(P), S-IV(P), S-V(P), S-VI(P) and third set of rock powders were mixed with equal quantity of 0.000652 M solution of potassium permanganate solution represented as S-I(KM), S-II(KM), S-II(CM), S-IV(KM), S-V(KM), S-VI(KM). Each mixture in a set was shaken for half an hour so that the surface of powdered rock surfaces and solution will be in contact for sufficient period of time. The mixture were filtered. The filtrate were examined for an absorbance in a λ_{max} which is fixed earliar for each solution in UV-VIS spectrophotometer. The readings were recorded.

3. RESULT AND DISCUSSION:

In all cases, absorbance obtained for each original solution was more than that of filtrates (Solution obtained as filtrate after mixing with different rock powders). This shows that the concentration of each solution decreases after mixing with rock powder. But the degree of absorption for filtrate of each rock powder were not similar. This is an indication of the degree to which different rock powders adsorbed a particular ions from their solutions. Since the absorbance of filtrate is inversely proportional to adsorption on solid rock powder, the more absorbance implies that lesser is adsorption on the solid surfaces. Taking the absorbance of the original solution (OS-II) as reference, the degree of adsorption on rock powder was arbitrarily calculated as the minus of absorbances of each filtrate of mixtures from the absorbance of the original solution (Ads = Abs of OS-II – Abs of filtrate).

From the experimental data it appeared that the degree of adsorption did not solely depend upon the pH of solution but seemed to be an independent property which is not influenced by pH. The following tables express the relation of different rock samples and their absorbances for selected ions.

Table-3.1: Absorbance of filtrate of different rock powders when treated with $CuSO_4$

S/NO	Sample{S-I(CS)toS-VI(CS)}	Color	pH	Absorbance (Abs)	Adsorption (Ads) on rock samples
1	S-I(CS)	Grey	6.6	0.053	0.053
2	S-II(CS)	Light grey	6.5	0.041	0.027
3	S-III(CS)	Brown	6.1	0.066	0.002
4	S-IV(CS)	Chesnut brown	5.9	0.059	0.009
5	S-V(CS)	Light brown	5.8	0.045	0.023
6	S-VI(CS)	Brick red	5.8	0.048	0.02
7	OS-I (CS)	-	-	0.078	-
8	OS-II (CS)	-	-	0.068	0.0

Rock sample with grey color with pH 6.6 shows the highest degree of adsorption of Cu^{2+}. Whereas Brown color rock sample with pH 6.1 displayed least adsorption. The order of absorbance of filtrates is OS-I(CS) > OS-II(CS) > S-III(CS) > S-IV(CS) > S-I(CS) > S-VI(CS) > S-V(CS) > S-II(CS). Therefore, the amount of adsorption of Cu^{2+} on different rock powder is in the order S-II (CS) > S-V(CS) > S-VI(CS) > S-I(CS) > S-IV(CS) > S-III(CS).

Table-3.2 : Absorbance of filtrate of different rock powder when treated with $K_2Cr_2O_7$

S/NO	Sample {S-I(P) to S-VI(P)}	Color	pH	Absorbance (Abs)	Adsorption (Ads) on rock samples
1	S-I(P)	Grey	6.6	1.381	0.381
2	S-II(P)	Light grey	6.5	1.105	0.642
3	S-III(P)	brown	6.1	1.080	0.667
4	S-IV(P)	Chesnut brown	5.9	1.037	0.71
5	S-V(P)	Light brown	5.8	1.345	0.402
6	S-VI(P)	Brick red	5.8	1.028	0.719
7	OS-I (P)	-	-	1.880	-
8	OS-II (P)	-	-	1.747	0.0

The maximum adsorption is shown by soil sample (S-VI) with brick-red color and pH 5.8. The least adsorption is shown by soil sample (S-I) with grey color and pH 6.6 .The order of absorbance of filtrate is OS-I(P) > OS-II(P) > S-I(P) > S-V(P) > S-II(P) > S-III(P) > S-IV(P) > S-VI(P). Therefore, the extent of adsorption of Cr^{2+} or $Cr_2O_7^{2-}$ on different rock powders is in the order S-VI(P) > S-III(P) > S-I(P) > S-II(P) > S-V(P) > S-IV(P)

Table-3.3 : Absorbance of filtrate of different rock powders when treated with $KMnO_4$

S/NO	Sample{S-I(KM) to S-VI(KM)}	Color	pH	Absorbance (Abs)	Adsorption (Ads) on samples of rock
1	S-I(KM)	Grey	6.6	0.379	0.508
2	S-II(KM)	Light grey	6.5	0.407	0.48
3	S-III(KM)	brown	6.1	0.378	0.509
4	S-IV(KM)	Chesnut brown	5.9	0.497	0.39
5	S-V(KM)	Light brown	5.8	0.408	0.479
6	S-VI(KM)	Brick red	5.8	0.340	0.547
7	OS-I (KM)	-	-	1.460	-
8	OS-II (KM)	-	-	0.887	0.0

Rock sample (S-VI) with color, brick-red and pH 5.8 showed the maximum adsorption for MnO_4^- .While, Sample (S-II) with light grey color and pH 6.5 showed the least adsorption. The order of absorbance of filtrate is OS-I(KM) > OS-II(KM) > S-IV(KM) > S-V(KM) > S-II(KM) > S-I(KM) > S-III(KM) > S-VI(KM). Therefore the degree of adsorption of Mn^{2+} or MnO_4^- on different rock powders is in the order S-VI(KM) > S-III(KM) > S-I(KM) > S-II(KM) > S-V(KM) > S-IV(KM).

The pH of different rock samples is given in the following table. From the measured value, pH value of different rocks ranges from 5.8 to 6.6 i.e. pH less than seven at 25^0C reveals that they are mostly acidic in nature.

Table-3.4 : Sample of different rock powders and their pH

S/NO	Rock samples	pH
1	S-I	6.6
2	S-II	6.5
3	S-III	6.1
4	S-IV	5.9
5	S-V	5.8
6	S-Vi	5.8

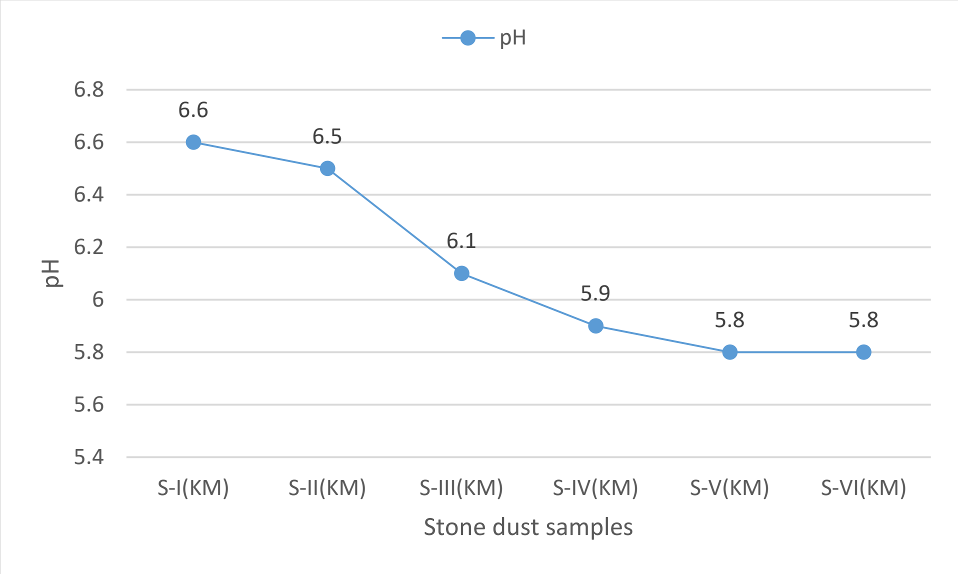

Figure-3.1: pH of different samples of rock powder

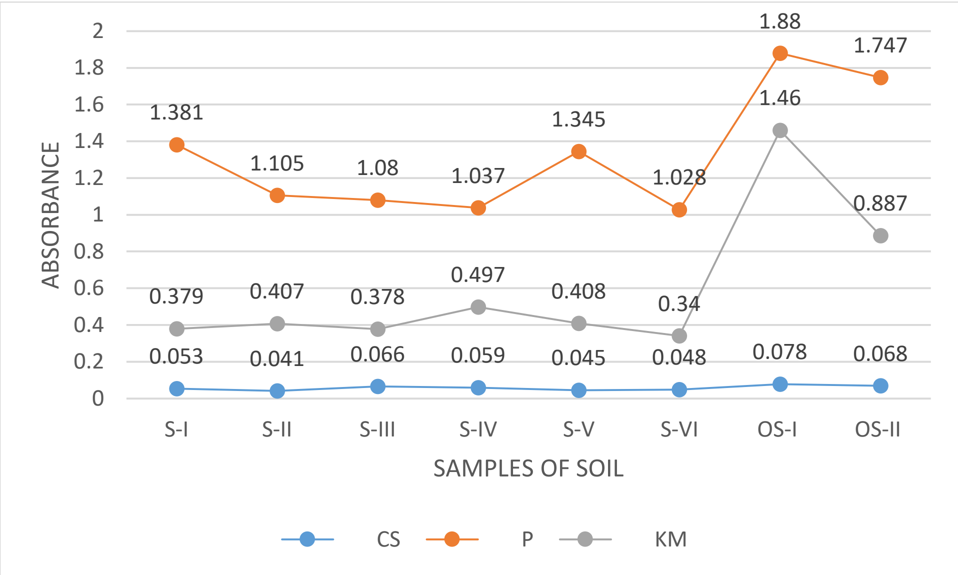

Figure-3.2: Graph showing absorbance of filtrates against different rock powders.

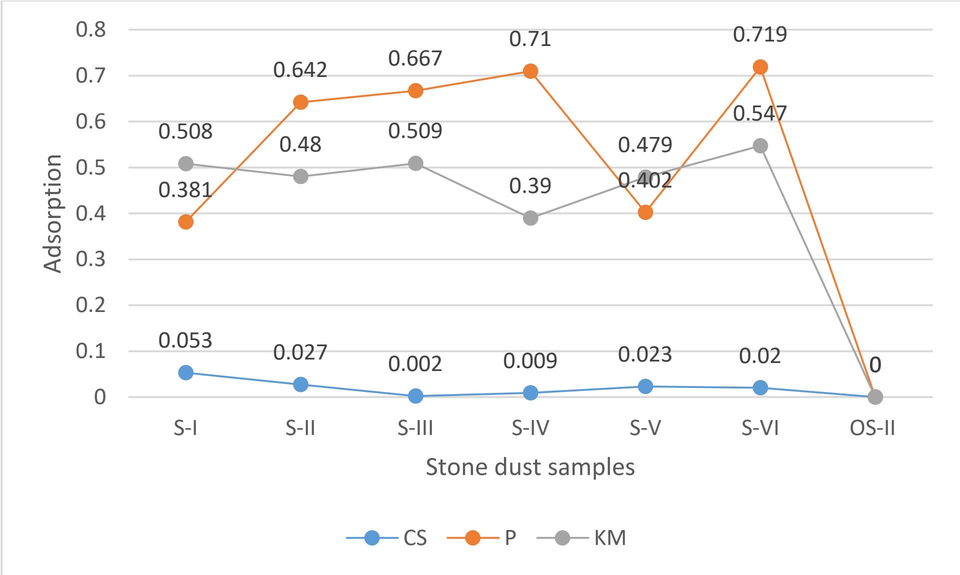

Figure-3.3: Graph showing adsorption of Cu^{2+} (CS), MnO_4^-(KM) and $Cr_2O_7^{2-}$ (P) against Rock powders

4. CONCLUSION:

From the investigation of different rock samples, it can be concluded that each sample of rocks adsorbs varying quantities of metal ions like Mn^{2+}, Cu^{2+}, and Cr^{2+} from their solutions. Rock of all types do not adsorb to the same degree but all types adsorb to some extent. From the data, it appears that pH of rock do not have much influences on the degree of adsorption. Whereas, Pore size, pore structures and chemical components of rock seem to be the dominating factors that influence adsorption of ions.

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