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Impact Assessment of Certain Ions as Pollutants Such as Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) Ions for Water Quality of The River Mohand Rao in Doon Valley

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Abstract:—Water is essential for the survival of any forms of the life on Earth. On an average a human being consumes about 2liters of water every day . . Hard water is that which has high mineral content (in contrast with soft water). Hard water has high concentrations of Ca^{2+} & Mg^{2+} ions .Hard water is generally not harmful to one's health but can pose serious problems in industrial settings.. In domestic settings, the hardness of water is often indicated by the non-formation of suds when soap is agitated in the water sample. The following equilibrium reaction describes the dissolving /formation of calcium carbonate scales:

$CaCO_3 + CO_2 + H_2O \rightleftharpoons Ca^{2+} + 2HCO_3^-$

Calcium and Magnesium ions can be removed by water softeners. In this paper we have investigated the variation of the total-hardness of the water of river Mohand Rao with respect to seasonal variations.

I. INTRODUCTION

Nature and mankind forms an inseparable part of the life supporting system . This system has five elements air, water, land flora and fauna which are interconnected , inter-related and inter-dependent and have co-evolved and are co-adopted. Deterioration in one inevitably effects the other four elements. If the deterioration is for a short term and the life supporting system had enough resilience , it repair itself and revert to the original state. However , if the deterioration continues , the whole systems including all lives are thrown out of gear. This disturbance of system is called the pollution , it may be in air, water, and land causing air-pollution , water- pollution and land-pollution. The total average annual flow per year for the Indian river is estimated as 1953Km3. The total annual replenishable ground-water resources are assessed as 432Km3. The annual utilized surface water and ground water resources of India are estimated as 690Km3 and 396 Km3 per year respectively. The importance of understanding the relationship between man and environment has never been so great as it is realized at present Industrial and Technological advancement being made throughout the world are undoubtedly contributing towards our property but creating problem of depletion of environmental resources and increasing pollution. Therefore , the need for conservation of resources and environmental protection, which are so intimately connected with our survival and sustainable development is being globally recognized. Pollution may be defined as any undesirable changes in physical, chemical or biological characteristics of air, land or water affecting the Life in harmful way. Pollutants gets dispersed in air, water and soil.The dispersion and movement of pollutants in the biosphere is a complex process and it accumulates within organism and causing toxic effects. Comprising over 80% of the earth's surface water is undoubtedly the most precious natural resources that exist on our planet . It is essential for all forms of life on our planet i.e. earth.Owing to increasing industrialization on one hand and exploding population on the other , the demand of water supply have been increasing tremendously. Moreover considerable part of this limit of water is polluted by sewage , industrial wastes and wide array of synthetic chemicals. According to Federal Water Pollution Control Act (F.W.P.C.A) the pollutants include degraded soil, solid wastes, incinerated residue, sewage , garbage, sewage sludge , chemical wastes , biological materials , heat , rock , sand , dirt , industrial wastes, municipal wastes and agricultural waste gets discharge into the river. In recent year many studies have been made in India to describe the stream morphology , hydrology, ecology of hill streams , river and details of their biotic communities inter-relation to water quality have been documented.

A number of studies have also been made to analyze the effects of industrial pollution on different rivers. However only a few studies have been conducted on land, water- interaction in the river basin.On analyzing the National Water Supply Sector Policy's objectives, policies and programs related to drinking water leads to several observations. First they emphasize on enlarging the drinking water coverage, but mere emphasis will not be adequate unless the quality (potable) and quantity (per capita) aspects of drinking water are considered. These two aspects of water are vital in terms of health and sanitation . Second , the health and sanitation education program to reduce water- related diseases will not be effective unless the water sector defines a Indian potable water standard.Further , the living standards of general rural communities must be raised by providing income generating activities. This will enable them to pay ever-increasing water and sanitation tariffs.However, this issues is not only relevant to the drinking water sector but interlinked with many other sector related to water sanitation, health. It requires a coordinate effort to be made at national , sub-national and local levels because water-related diseases relate to all form of life. Here we analyze the water quality of the particular river Mohand flowing in the Doon valley to prevent the water born diseases as large populations of Van-Gujjars depends upon this river for their velhoods.

II. METHODOLOGY

a) Geographical Area

Dun; Doon; Dhoon in the Sanskrit and Hindi languages means a "Valley" which has not been made by river soil erosion ,but is formed by Tectonic Activity within the earth that causes movements of its crusts, as earthquakes, folds, faults or the lake.The Oxford Dictionary defined it as - *"Valley in Shiwalik Hills"*There are number of valleys large and small between the Sub-Himalayas and the Shiwalik Hills. "Valley of Doon" is on the North-West part of the Indian state of Uttar-Pradesh.The Doon Valley is situated between the latitude of 30^0 to 30^0 32' and longitude of $77^0$43' to 78^0 24' It is nearly 75Km long from North-West to South-East and 25Km broad from the North-West to South-West.Region of Doon valley involves two distinct styles and amplitude of folding. In the northern part, the over turned **SANTAURGARH ANTICLINE** with both limbs dipping steep to moderate was developed as fault propagated fold over the **SANTAURGARH THRUST (ST)**.The uplifted hanging wall of the Santaurgarh Thrust constituted the dissected SHIWALIK and the down faulted footwall formed the pedimented Shiwalik.To the south in the frontal range, the Shiwalik strata were folded into **MOHAND-ANTICLINE. MOHAND ANTICLINE** as fault-bend folds over the **HIMALAYAN FRONTAL THRUST (HFT)**.The uplifted terraces on the fore-limb of the anticline resulted due to displacement on the **HIMALAYAN FRONTAL THRUST (HFT)** in Holocene. The Bhanwala Thrust,Majhaun Fault and Asan Fault were formed as out of sequence thrust within the **MAIN BOUNDARY THRUST(MBT)** .**Himalayan Frontal Thrust (HFT)** wedge of folded Shiwalik and overlying Dun gravel subsequent to Santaurgarh thrust.The Garhwal Himalaya geographically forms the central part of the Himalayan organic belt that runs in an arcuate shape for a strike length of about 2400Km with width varying from 230Km to 320Km and represent a classic example of collision type mountain belt.Continued tectonic activity also produced nappes in the lesser Himalaya which was pushed due south along the **MAIN BOUNDARY THRUST (MBT)** and **HIMALAYAN FRONTAL THRUST (HFT)**. Stacking of thrust slab caused differential loading and depressed the frontal part of the Indian plate in front of the advancing nappes, thus producing sag or a foreland basin in front of the rising Himalaya. The "Garhwal – Himalaya "demarcates more or less Western and Eastern boundaries by the river Yamuna and Ramganga (Bist & Choudhry .1993). The region is mainly covered by the drainage basin of the "Holy-Ganga" and its tributaries which have carved out stupendous gorges for most part of their length and thus present one of the best exposed sections of the Himalaya for study.

III. DRAINAGE SYSTEM

A drainage system is the pattern formed by the streams, rivers and lakes in a particulardrainage basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks and the gradient of the and.Geomorphologists and Hydrologists often view streams as being parts of drainage basins. A drainage basin is the topographic region from which a stream receives run –off, throughflow and ground water flow. Drainage basins are divided from each other by topographic barrier called as watershed. A water-shed represent all of the stream tributaries that flow to some location along the stream channel .District Saharanpur is situated in the North of Uttar-Pradesh. In the North of district Saharanpur on the Shiwalik range, there is district Dehradun in the south there is district Muzzaffarnagar and district Haridwar in the east. Yamuna river lies in the west made boundaries with district Karnal and Yamuna-nagar.Many rivers flows through Saharanpur viz Solani among these are the river Mohand Rao. Mohand Rao river originated from near a emple Dat-Mandir It is about 18Km in length and flow from Dat-Mandir via Iron –Bridge ;Mohand village ; Khushalipur; Ganeshpur; Tanda-Man Singh;Biharigarh and then falls in Solani river near Amanatgarh village which then via Khedi-Shikopur;Hasanpur ;Madanpur; Khubbanpur; Landhora & then falls in Ganga river near Luxor. The location of Saharanpur on globe is on latitude of $29^0$58' North and Longitude $77^0$33', East .While the height from the Sea-Level is 270.50 meters Presently, study was carried out on the stretch of 15Km from Dat-Mandir to Ganeshpur of the water of river Mohand Rao . Mohand-Rao river flowing in the Doon Valley at the height (from the sea-level)=270.50meters

Latitude	29^0 58'
Longitude	77^0 33'
Length of River	20Km
Width of the River	5 to 100 meters
Minimum depth is	0.10 meters
Maximum depth is	0.50 meters
Mean depth is	0.30 meters

River Mohand rao flowing in shiwalik region of Himalayas means through the lower hills of Himalayas is apart of the Ganga river system in the foot hills of Himalayas. The word Rao is given to the River by British because of the availability of small white stone in the flowing stream.

IV. MAP OF THE RIVER MOHAND RAO FLOWING IN THE FOOTHILLS OF HIMALAYAS

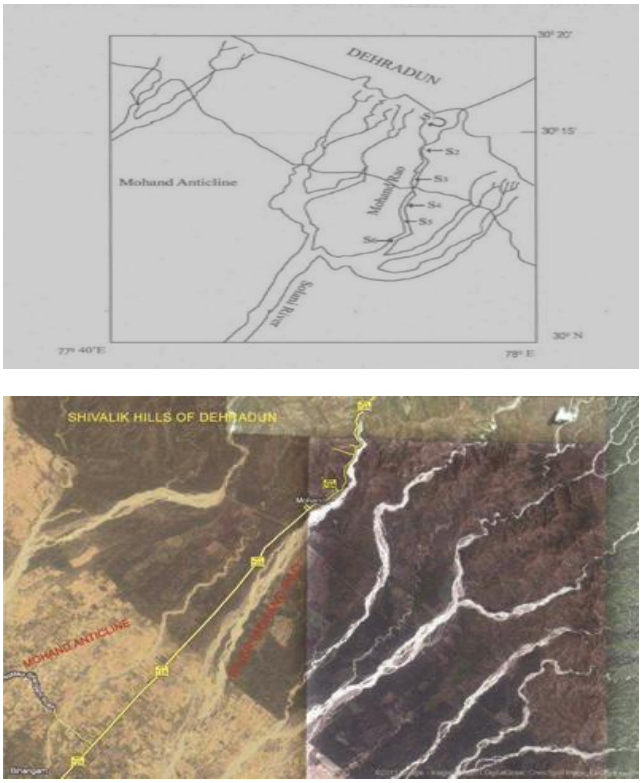

Fig : *Map showing origin and flow of River Mohand-Rao and also showing locations of Six Study Sites*

S1 = Sampling station 1 S3 = Sampling station 3 S5 = Sampling station 5
S2 = Sampling station 2 S4 = Sampling station 4 S6 = Sampling station 6

River Mohand Rao originated from near a temple Dat-Mandir and lastly falls in to the river Solani near Amanatgarh village.The importance of water begins with the beginning of water itself. Man's interest in water is as old as the history of man himself on the earth. Life is supposed to have originated in water and is the most essential requirement of all lives. Poet Atonine in his poem "WATER" said – "you are not necessary to life you are life" and we all agree that water is life, as we cannot think of life without water. The maintenance of a healthy aquatic ecosystem is dependent on the Physico-Chemical properties of water and the biological diversity. The physico-chemical parameters are important for assessing the water – quality. The main purpose of analyzing the physical and chemical characteristics of water is to determine its pollution status. In facts the final status of a water body is conditioned by these factors and the status of the water is really the result of interaction of these factors. Water quality monitoring is the basic need for the people who rely on river water for their day to day usages. In this context, a stretch of 15 km from Dat-Mandir to Ganeshpur of the Mohand-Rao river(Doon valley) was studied during the year 2004 and 2006. The study revealed that, the river water is free from pollutants; however, the study stressed the need to keep the flow condition in a optimal stage. Six places were selected randomly and from each selected places Five samples of water of each season (i.e Summer, Monsoon, Winter) were collected. Each sample were analyze for knowing the total hardness of Mohand river with respect to the seasonal variation.

V. RESULT

Surface water analysis for Chemical Mass Balance

Six surface water samples were collected from selected locations in the present study only major cation that causes hardness such as Calcium and Magnesium were determined by using standard methods (APHA 1995)

Calculation of water quality index (WQI) : The water quality index was calculated by taking the weighted arithmetic mean of the quality rating using following formula adopted by various investigator (Swarnalatha et al 2007; Dwivedi & Pathak 2007; Shanker & Balasubramanya2008)

WQI= [SqiWi]/[SWi]

Here ,SWi =1 was considered . Both the summation were taken from i= 1 to i=n=3

(i.e, the total number of parameters considered in the present study).

The status of water quality based on WQI was evaluated as per classifications adopted by various Investigator (Asad et al 2007, Shah et al 2008)

Table-1 : Classification of river water based on Water-Quality-Index

WQI value Status	Category
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
	Above 100 Unsuitable for drinking

VI. SURFACE WATER CHARACTERISTICS-

Assessment of water quality today in global terms implies the need for a reference point against which the results of monitoring can be measured and weighted. An attempt is made to define and describe natural water quality to the extent possible and scientifically justifiable . Aquatic ecosystem as a part of the natural environment are balanced both within themselves and other environmental compartments and this equilibrium is subject to natural variations and evolutions as well as variations caused by human interventions .It is the ambition of the present assessment to identify the anthropogenic influences over time against a natural baseline situation . Water quality analysis results on the distribution of Calcium ions along the stretch of the river, showed an overall increase in the percentage of Calcium ion from year 2004-2006

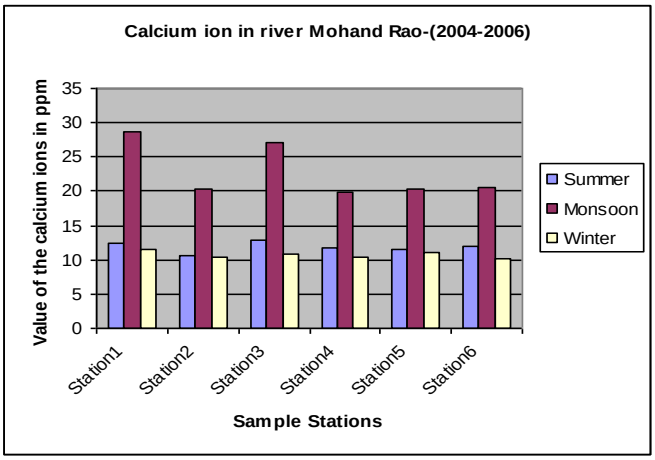

Figure-1 *Seasonal Variation of Calcium during the year 2004-2006*

The value of Calcium was found to be maximum in the month of monsoon at station-1 while it was found to be lowest in the month of winter at station-6 while other ranges were found to be average except in the month of monsoon at station-3 which was found to be high.Magnesium ions are quite prominent in all the samples. The percentage was less during the summer and winter months . Magnesium ions showed a considerable increase during the rainy season followed by drastic decline during the winter months . It is also noted that the concentration of Magnesium ions is lower in the year 2005 in comparison to the year 2004.The concentration of Magnesium ions normally depends on the extent of solubility under different environment

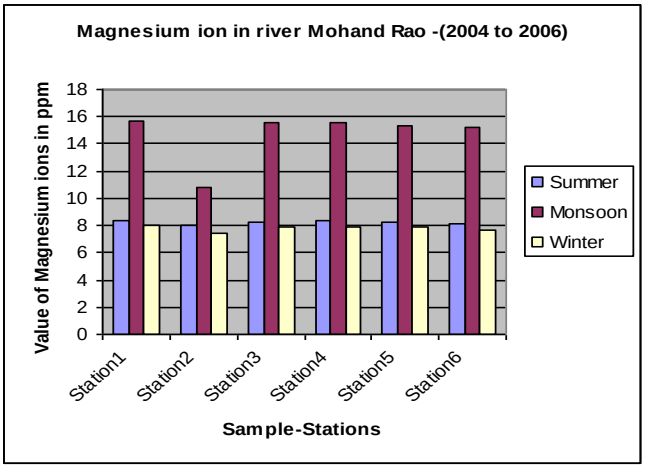

Figure-1 *Seasonal Variation of Magnesium during the year 2004-2006*

The value of Magnesium was found to be maximum in the month of monsoon at station-1 while it was found to be lowest in the month of winter at station-2 other station showed average values. Water Quality Index: Table1 shows the Water Quality Index developed for the study area considering Calcium ion and Magnesium ions.

Table1: Water Quality Index determined for individual ions during different Season

	Year-2004			Year-2005		
Ions	Summer	Monsoon	Winter	Summer	Monsoon	Winter
Calcium	4.041	7.772	3.583	4.179	7.538	3.741
Magnesium	17.398	30.986	16.709	18.088	32.235	16.796
Total	21.439	38.758	20.292	22.267	39.773	20.537
Category	Excellent	Good	Excellent	Excellent	Good	Excellent

Water Quality Index of various seasons indicate the water quality of the river basin is categorized as excellent for drinking and other domestic purposes. However, during the rainy season it showed a very high index value due to the increase in cations like Calcium ion and Magnesium ions. The reason in this case is obvious , i.e . during the rainy season the rain water carries lot of sediment along with various kinds of pollutants from the catchment areas and enter the river water due to overland flow. The process of overland flow is the main cause of non-point source of pollution in all river basin.

VII. CONCLUSIONS

1- Water-Quality analysis of alkali and alkaline earth metals show that water of the studied river Is very good for drinking purpose.
2- Study also revealed that there is an increase in measured parameters from year 2004 and 2005 which may need a long term monitoring station for further conclusion.
3- A clearcut impact of manmade disturbance is evident in certain stations which showed
a declining trend of water quality .

VIII. DISCUSSION

The above result so obtained from the chemico-physical analysis of the water of flowing stream in the hilly areas of Himalayas .These data's so obtained are gets involved to determine the STANDARD DEVIATION (S.D) in statistical data analysis –

$$S.D=\sqrt{n\sum x^2}/n-1-\sqrt{(\sum x)^2}/n-1$$

On this formula of standard deviations the mean and Analysis of variation were calculated ,hence whole data analysis depends upon the above stated formula

TABLE-1

Mean of the Calcium ions (Ca^{2+}) in the water at six station accordingly to season

SAMPLE	**SUMMER**		**MONSOON**		**WINTER**	
	MEAN	**S.D.**	**MEAN**	**S.D.**	**MEAN**	**S.D.**
1	12.46	0.49	28.67	0.45	11.62	0.38
2	11.05	0.22	20.74	0.38	10.33	0.27
3	12.76	0.38	27.20	0.84	10.76	0.78
4	10.32	3.90	19.89	0.19	10.28	0.43
5	11.47	0.59	20.21	0.32	11.15	0.47
6	10.70	3.30	20.60	0.30	10.26	0.30
TOTAL=	11.46	2.30	22.88	3.64	10.73	0.69

ANOVA - Analysis of variation

Sources	**df**	**S.S**	**M.S.S**	**F**	**P**
Between Season	2	4459.9737	2229.99	558.81	<0.001
Between Station	5	367.9827	73.59	18.44	<0.001
Error	136	542.7235	3.9906		
Total=	143	5370.68			

df→ degree of freedom. F→ Test of Significance
SS→sum of square P→ Probability Level

MSS→Mean sum of square SD→Standard Deviation

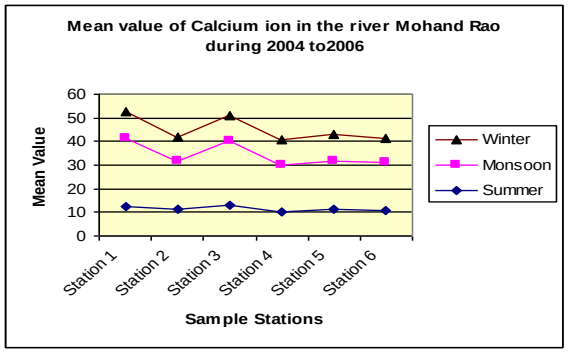

Fig : *Mean Value of Calcium ion in the river Mohand Rao during 2004 to 2006*

Mean of the Calcium ions (Ca^{2+}) during Summer observed to be 11.46 which was maximum at 12.76 at station-3 and minimum at 10.32 at station-4 similarly during Monsoon the average of Calcium ions (Ca^{2+}) in water was 22.88 with a maximum of 28.67 at station-1 and minimum of 19.89 at station-4. Now during winter the average of Calcium ions (Ca^{2+}) in Winter was 10.73 with maximum of 11.62 at station-1 and minimum of 10.26 at station-6.

1. **ANOVA** Analysis of above data reveals that the significant differences regarding mean of the Calcium ions (Ca^{2+}) was observed between season as well as station (P=<0.01). Calcium is one of the most abundant substances in the natural water. It is introduce in water by passage over limestone and other such deposits. It is the element largely responsible for the hardness of water , thereby reducing the utility of water for domestic and industrial purposes.

TABLE-2

Mean of the Magnesium ions (Mg^{2+}) in the water at six stations accordingly to season

SAMPLE	SUMMER		MANSOON		WINTER	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
1	8.40	0.30	15.43	0.30	7.88	0.37
2	8.06	0.12	10.78	0.56	7.41	0.22
3	8.21	0.23	15.57	0.40	7.90	0.10
4	8.37	0.36	15.54	0.28	7.86	0.20
5	8.28	0.27	15.29	0.20	7.94	0.26
6	8.12	0.30	15.17	0.24	7.67	0.31
TOTAL=	8.24	0.30	14.68	1.79	7.78	0.32

ANOVA – Analysis of variation

Source	df	S.S.	M.S.S	F	P
Between Seasons	2	1428.9808	714.4904	989.59	<0.001
Between Stations	5	64.9964	12.9993	18.00	<0.001
Error	136	98.1808	0.722		
Total	143	1592.16			

df→degree of freedom F→Test of Significance
S.S.→Sum of Square P→ Probability level
M.S.S.→Mean Sum of Square S.D.→Standard Deviation

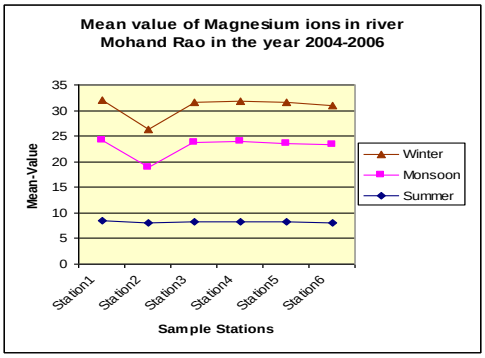

Fig : *Mean Value of Magnesium ion in the river Mohand Rao during 2004 to 2006*

Mean of the Magnesium ions (Mg^{2+}) in the river water during Summer observed to be 8.24 which was maximum at 8.40 at station - 1 and minimum at 8.06 at station – 2 Similarly during Monsoon the average of Magnesium ions (Mg^{2+}) in water was 14.68 with a maximum of 15.73 at station –1 and minimum of 10.78 at station – 2. Now during Winter the average of Calcium ions (Ca^{2+}) in Winter was 7.78 with the maximum of 7.94 at station - 5 and minimum of 7.41 at station – 2. **ANOVA** – Analysis of above data reveals that the significant difference regarding mean of the Calcium ions (Ca^{2+}) was observed between season as well as station (P=<0.01). Magnesium rank eighth among the element in order of abundance and is a common constituent of natural water. Magnesium occurs in all kind of natural water with Calcium but its concentration remain generally lower than Calcium.The principal sources in the natural water are various kinds of rocks. Magnesium is an important contributor to the hardness of water . Magnesium salts break down on heating to form scale in boiler.Magnesium is supposed to be non – toxic at the concentration generally met with in natural water.

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