

## STUDY OF MONGHOPIR SPRING WATERS

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### ABSTRACT

The present investigation of the waters of the hot and warm springs of Monghopir area in Karachi County, Sind, shows that they are significantly different in their physical properties and chemical composition.

Geochemical behaviour of the chemical constituents of the waters have been discussed. Possible causes of changes in chemical composition of waters have also been described.

### INTRODUCTION

Reference to the occurrence of thermal springs in Indo-Pakistan subcontinent is found in many reports of the last century. A summary of information on the occurrence of thermal springs of this subcontinent was published by MACPHERSON [1854] and later on by SCHLAGINTWEIT [1864]. OLDHAM [1882] also published a catalogue of the hot springs known at that time. GHOSH read his presidential address on the thermal springs of Indo-Pakistan subcontinent in the Indian Science Congress held in 1950. Later works of the officers of the Geological Survey of Pakistan added informations on the occurrence of thermal springs in Pakistan.

At present the occurrence of springs are reported from the northern part of Hyderabad Division of Sind which includes the hot springs described in this paper, in the Punjab, specially the Salt Range area, Baluchistan, N. W. F. P., Gilgit, Baltistan and Chitral, but no work on the origin, discharge, accurate temperature record, chemical composition, radio-metric studies and therapeutic value has yet been done.

The present paper comprises a physical and chemical studies of the waters of hot and warm springs of Monghopir, Sind, to find out the causes which are playing significant role in changing the chemical composition and properties of the spring waters.

The chemical analysis data have also been used to study the geochemical behaviour of the elements and the compositional correspondence between the waters of the hot and warm springs. The only reference to the study of these springs was made by RAFIQUZZAMAN and MEHDIHUSSAN [1964] from therapeutic point of view, furnishing no analytical data. As yet no information is available on the above mentioned objectives for the waters of the two springs which differ appreciably from the other cold springs of the region. This attempt is first of its kind.

GENERAL GEOLOGY

The hot and warm springs of Monghopir are situated in Karachi county, at a distance of about 15 miles north of Karachi University. The distance between the two springs is about two furlongs and both are oozing out along the fault plains in Gaj Limestone. Apparently these springs differ in their temperature and the amount of hydrogen sulphide and carbon dioxide evolution which come out on the surface in the form of bubbles.

Besides the hot springs in Monghopir village there are quite a number of springs in the locality such as Khari Lakki, Ziarat and Lal Chakro etc, but they do not posses similar properties as mentioned above for the hot and warm springs. On the contrary the water of Lal Chakro spring is used for drinking purpose by the local inhabitants.

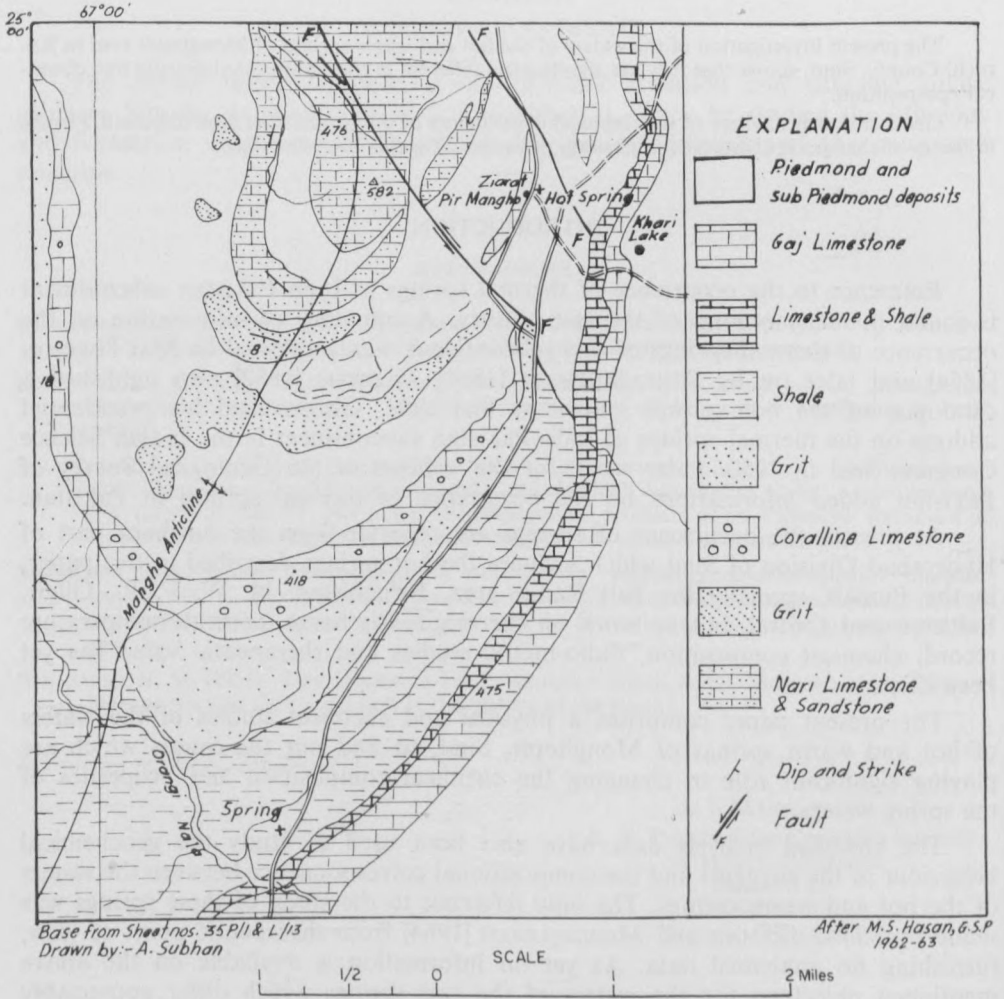


Fig. 1

The rocks exposed in the area of Monghopir are Nari, Gaj and Manchat formations of Oligocene, Miocene and Pliocene ages respectively (*Fig. 1*). Nari Formation is mainly composed of sandstone, limestone and shales. The sandstone is medium to coarse grained in general but gretty character and iron concretion can also be seen in the sandstone bed. The cementing material is argillaceous to ferro-argillaceous which weathers to brown, rusty brown, yellow and dark grey from its original grey and light brown colour. The sandstone is loose, friable and highly porous. Horizontal and vertical joints are common.

The brown Nari shale is found interbedded with the limestone and the sandstone. The abnormal thickness of the shale varies from 256 to 335 feet but thin layers appearing as parting between the two beds of the limestone and the sandstone are also common. Iron concretions are rare in the shale, but gypsum is commonly found. The colour is generally grey but red, green, yellow and variegated colours also be seen.

The fossiliferous limestone is found above the Nari sandstone, in five different beds alternating with the sandstone and shale layers. Joints are less developed in the lower most bed of the limestone but the upper beds are appreciably jointed. The chemical analysis shows the dominance of silica and argillaceous matter, besides a high percentage of calcium carbonate. The topmost bed of Nari Limestone is highly fossiliferous. Among the fossils, forams and corals are the dominant indicators of life at the time of deposition of Nari Formation.

Coralline limestone of cream colour stands out between the top of Nari Formation and the base of the Gaj Formation. The age of this limestone is still a matter of dispute.

#### GAJ FORMATION

Gaj Formation comprises of limestone, shale and sandstone in order of their abundance. The total thickness of the formation is 1300 feet. The limestone is argillaceous and porous but hard and resistant to weathering to a great extent. Fossils are abundant in this limestone and at some places it appears to be formed of shells and tests only. Cavity formation and presence of horizontal and vertical joints are common features of this limestone.

The shale is gypsiferous and grey in colour. It is soft, fine grained and loose in texture. The shale is found alternating with the grey sandstone.

The grains of the sandstone are moderately rounded and medium in size. The texture of the sandstone is loose due to argillaceous cement. Iron concretions are common.

Cracks and joints developed in the limestones and sandstones are numerous and are widened as a result of solution action. These craks and joints enhance the effective permeability in the sandstone and limestone for ground water accumulation in the area.

#### PHYSICAL PROPERTIES OF THE SPRING WATERS

In Monghopir the spring sites are about 582 ft above sea level. Though the distance between the two springs described is about two furlongs but the hot spring gives a discharge of about 1200 gallons of sulphurated water per day as compared to the warm spring which discharges only 500 gallons of water in a day (KDA report 1963) and no smell of sulphurated hydrogen gas is felt in it.

Besides the prominent difference in the quantity of discharge of waters from the hot and warm springs and the dissolved gasses in them, they also show an appreciable difference in their hardness, electrical conductivity, pH condition and turbidity of water (Table 1). Specific gravity, surface tension and viscosity, the refractive index of the water also show some differences but these properties are not as distinctive as the other characters determined for the present work.

TABLE 1

*Physical properties*

No.	Characteristics	Hot spring	Warm spring
1.	Colour	Under 0.5	Lovibond unit yellow
2.	Odour	Smell of H <sub>2</sub> S	None
3.	Taste	Slightly Saltish	Slightly Saltish
4.	Temperature	47 °C	38 °C
5.	Turbidity	0.5	0.1
6.	Specific Gravity	1.0016	1.0019
7.	Surface tension	71.77	70.95
8.	Viscosity at 31.5 °C	0.00782	0.00781
9.	Electrical Conductivity at 35 °C	0.00286	0.00350
10.	Refractive Index	1.3328	1.3327
11.	Permanent Hardness	31.5 ppm	56.4 ppm
12.	Total Hardness	271.5 ppm	371.5 ppm

GEOCHEMICAL STUDY

Standard classical chemical analysis methods were used for the quantitative analysis of major and important minor components of the waters collected from the hot and warm springs.

The result of chemical analysis shows a marked antipathic trend of enrichment and depletions for Ca and K in the waters of hot and warm springs. The concentration of calcium is very high (88,88 ppm) in warm waters as compared to the hot water which contains only 26,28 ppm, but reverse is true for the concentrations of potassium (Table 2).

The concentration of magnesium is relatively higher in hot water than the warm water of the spring (Table 2). There is not much difference in the iron content of the two waters.

The content of sulphate, nitrate, consumed oxygen, albuminoid ammonia and evaporites are significantly higher in warm water than in the hot water, but reverse is true for the concentration of free ammonia and hydrogen sulphide which is practically absent in warm water.

TABLE 2

*Chemical properties*

No.	Characteristics	Hot spring (ppm)	Warm spring (ppm)
1.	Hydrogen sulphide	0.034	Nil
2.	Nitrite	0.002	0.001
3.	Nitrate	0.320	0.369
4.	Chloride	424.00	600.00
5.	Sulphate	217.51	336.69
6.	Phosphate	Nil	Nil
7.	Silicate	(in traces)	(in traces)
8.	Alkalinity	240.0	315.0
9.	Consumed Oxygen	0.15	0.2
10.	Free ammonia	0.024	0.004
11.	Albuminoid ammonia	0.052	0.084
12.	Calcium	26.28	88.88
13.	Magnesium	34.52	28.93
14.	Potassium	24.80	14.56
15.	Iron	0.12	0.10
16.	Evaporates (qt 120 °C)	1394	1752
17.	pH	8.20	7.2

Silica was found in traces only in hot water. Phosphate content was not found in either of the water samples.

The water samples of both springs are alkaline, but the sample of warm spring shows more alkalinity as compared to the hot spring water.

## DISCUSSION

If it is assumed that there is an average increase in temperature of 1 °F at every 100 ft of depth below the surface of the earth then the temperatures of the hot (140 °F) and warm (126 °F) springs show a depth of about 1400 and 1260 feet respectively for the source of waters. The calculated values of depth do not give the correct depth of the source, because some of the heat energy is also being dissipated in the channels and in the rocks through which they pass. The loss and gain of heat due to exothermic and endothermic reactions at the source or in the channel is also not beyond possibilities.

Thus it seems fair enough to conclude that the temperature of waters of the two springs are not related only to the depth of the source of waters, but the reasons mentioned above are also playing significant role.

The difference in chemical composition of waters of the springs seem related more to the temperature conditions than to the depth and the area of catchments of the two springs.

The great difference in discharge of water of the hot (1200 gallons/day) and warm (500 gallons/day) springs may be due to the difference in extent of catchment areas or some subsurface flow of water may be connected to the channel of the hot spring.

The absence of hydrogen sulphide in the warm spring and the presence only in the hot spring (0,034 ppm) is either due to dissolution of gypsum from gypseous shale of Nari age in the hot water coming from inside or the hot water is passing through such a channel of rocks which contains sulphides or sulphates. The decomposition of sulphides or sulphates may be the source of hydrogen sulphide gas but the chances are very remote due to absence of any sulphide deposits in this region. It is true that under normal conditions, hydrogen sulphide is not formed at higher pH values, but in nature specially in the subsurface where temperature and pressure are higher and physico-chemical conditions are complex, the acidic water after reacting with the sulphates or sulphides would have proceeded upward on way to the mouth of the springs with changes towards slightly alkaline state (8.2). Relatively higher content of consumed oxygen in warm spring is an other support to the arguments given above. The lower content of sulphate in the hot (217,51 ppm) as compared to the warm (336,69) spring also favours the present statement. The possibility of formation of hydrogen sulphide through the reaction between sulphates and organic acids formed due to the decomposition of organic matter can not be neglected. A secondary channel for the supply of hydrogen sulphide may also be considered as one of the causes.

Higher percentage of calcium in the warm spring (88,88 ppm) as compared to the hot spring (26,28 ppm) does not favour the possibilities of formation and concentration of  $H_2S$  simply due to the decomposition of gypsum. Magnesium appears to be in antipathic relationship with calcium. The trend of enrichment and depletion for K is the same as for magnesium.

The antipathic relationship of Ca & Mg does not seem completely in accordance with ATKINS [1939] observations who explains that Mg is readily soluble above pH 9 while calcium precipitates above a pH value of 11. The present observation shows that even at lower pH values of 7 to 8 the solubility of magnesium and calcium is affected if higher temperature condition is attained. The trend of K in the two springs following the concentration of Mg is due to its higher affinity with magnesium [RANKAMA & SAHAMA p. 431—34].

The absence of phosphorous in the two waters shows that no minerals or fossils containing phosphorous are present at the source of the waters and in the channels through which they pass. The observation also gets support from the known fossils of Nari and Gaj limestones of the area which contain mainly calcium carbonates in their chemical composition.

The presence of silica only in traces in the waters of the springs passing through argillaceous limestone and sandstones indicate acidic condition of waters. It could also be possible that waters at the source are incompetent to dissolve such constituent which require higher alkalinity to decompose the minerals or rocks.

Relatively higher amount of nitrates in warm water as compared to the hot water of the springs also seems to be sensitive to the alkalinity of the water.

The presence of higher amount of sulphate in warm spring could have been due to the decomposition of the gypsum.

The formation of sulphate seems sensitive enough to the chemical conditions and so the amount of sulphate is less in hot spring which has relatively higher alkalinity (8.2).

Chlorides show the same tendency of enrichment and depletion as the sulphates. It appears that the concentration of sulphate, nitrate and chloride is favoured in neutral to slightly alkaline chemical environment.

MACPHERSON [1854] states that probably the hot spring water of Monghopir is arsenical and so it is used for the remedy of skin diseases.

The chemical analysis of the water for present study does not show the presence of arsenic within the detection limits in waters of the hot and warm springs of this region. MACPHERSON's statement seems to be hypothetical as he did not make any chemical analysis of the waters. Moreover, he did not consider that sulphur in different states is also used as good insecticides. Therefore, it is possible that the remedy of skin diseases for which the waters are being used is due to the presence of sulphur in different forms and not the arsenic.

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