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Monitoring of Physico-Chemical and Microbiological Analysis of Under Ground Water Samples of District Kallar Syedan, Rawalpindi-Pakistan

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Abstract

Physico-chemical and microbiological study of groundwater and municipal water in Kallar Syedan is presented here by taking water samples from five different stations. The study was carried out by collecting five underground water samples (two open well, two bore) and one municipal water sample during April 2011-July 2011. The results were compared with standards prescribed by WHO and ISI 10500-91. The parameters including pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, dissolved oxygen (DO), total alkalinity (TA), total hardness (TH), calcium (Ca^{2+}) magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), nitrate (NO_3^{-}) sulphate (SO_4^{2-}), phosphate (PO_4^{3-}) and bacterial count (MPN/100 ml coliforms) were analyzed. It was found that the underground water was contaminated at few sampling sites namely Tayala and Luni. The sampling site Bhakral showed physico-chemical and microbiological parameters within the water quality standards and the quality of water are good and it is fit for drinking purpose.

Keywords: COD, DO**,** groundwater, physico-chemical analysis, municipal water, drinking water.

Introduction

Water is extremely essential for survival of all living organisms. Over one billion people worldwide have no access to safe drinking water[1].The quality of water is vital concern for mankind since it is directly linked with human welfare. Since it is a dynamic system, containing living as well as nonliving, organic, inorganic, soluble as well as insoluble substances. So its quality is likely to change day by day and from source to source. Any change in the natural quality may disturb the equilibrium system and would become unfit for designated uses. The availability of water through surface and groundwater resources has become critical day by day. Only 1% is available on land for drinking, agriculture, domestic power generation, industrial consummation, transportation and waste disposal[2-4]. The problems of groundwater quality are much more acute in the areas which are densely populated, thickly industrialized and have shallow groundwater tables. The rapid growth of urban areas has further affected groundwater quality due to over exploitation of resources and improper waste disposal practices. Hence, there is always a need for and concern over the protection and management of groundwater quality[5]. The consequence of urbanization and industrialization leads to spoil the water. For agricultural purposes ground water is explored in rural areas especially in those areas where other sources of water like dam and river or the canal is not available. During last decade, this is observed that the ground water get polluted drastically because of increased human activities[6-8]. Pakistan is among few developing countries where access to safe drinking water falls below satisfactory levels. A recent independent study reports that no more than 25% of the population has sustainable access to quality drinking water[9]. Ideally, drinking water should not contain any microorganisms known to be pathogenic or any bacteria indicative of faecal pollution. Detection of faecal indicator bacteria in drinking water provides a very sensitive method of quality assessment[10]. Their presence can be taken as an indication of the potential danger of health risks that faecal contamination poses[11-13]. Therefore, monitoring the quality of water is one of the essential issues of drinking water management[14-15].

Considering the above aspects of groundwater contamination, the present study was undertaken to investigate the possible impact of the groundwater quality of some open wells and one municipal water sample in different locations of district Kallar Syedan. Thus, in this research work an attempt has been made to assess the physico-chemical and microbiological parameters of groundwater like, pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, dissolved oxygen (DO), total alkalinity (TA), total hardness (TH), calcium (Ca^{2+}) magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), nitrate (NO_3^{-}), sulphate (SO_4^{2-}) and phosphate (PO_4^{3-}) of open well and bore well were determined. The analyzed data were compared with recommended WHO standard values[16].

Material and Methods

People at different locations of Kallar Syedan are using open well water, tube well water as well as municipal water for their daily need. The literature survey reveals that no water quality management studies were made in this region so far. Hence the present study was planned and undertaken. Water samples from five sampling points i-e. Nandna and Tayala (tube wells), Luni and Bhakral (open wells) and Mera Sangal (municipal water supply) of district Kallar Syedan were collected during a period of four months (April 2011 to July 2011).

Preparation of Water Samples: The samples were collected from all locations during a period of four months (April 2011 to July 2011) for physico-chemical and microbiological analysis, different methods of collection and handling were adopted based the standard procedures[17]. The samples were collected in plastic canes of three liter capacity without any air bubbles. The temperature of the samples was measured in the field itself at the time of sample collection. The samples were kept in refrigerator maintained at 4°C. The sampling locations and their source are given in table-1

Table-1
Sampling locations in Kallar Syedan

Sample No.	Sampling Locations	Source
SP-1	Nandna	Tube Well
SP-2	Tayala	Tube Well
SP-3	Luni	Open Well
SP-4	Bhakral	Open Well
SP-5	Mera Sangal	Municipal Water Supply

Physico-chemical Analysis: Physico-chemical analysis was carried out for various water quality parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, dissolved oxygen (DO), Chemical Oxygen Demand (COD), total alkalinity (TA), total hardness (TH), calcium (Ca^{2+}) magnesium (Mg^{2+}), sodium ($Na^{=}$), potassium (K^{+}), chloride (Cl^{-}), nitrate (NO_3^{-}), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}) using standard method[18-20]. The reagents used for the analysis were AR grade and instruments are of limit of precise accuracy.

Microbiological Analysis: Microbiological quality of water was determined using most probable number (MPN) methods[21]. The test was performed within 24 h of sample collection. The MPN method was used to determine the presence of gas producing lactose fermenters and most probable number of coliforms present in 100 ml of water. The standard MPN method (nine multiple tube dilution technique) was used for detection of total coliforms by inoculation of samples into tubes of lactose broth (LB) and incubation at 37°C for 48 h. The positive tubes were sub-cultured into Brilliant Green Lactose Broth (BGLB) and were incubated at 44.2°C for 48 h and checked for total count.

Results and Discussion

The physico-chemical and microbiological parameters exhibited considerable variations from sample to sample. All the measurements were carried out in the vicinity of temperature 40°C. The average results of the physico-chemical and microbiological parameters for water samples were presented in table-2. The results are also analyzed graphically as shown in figures below. It was thought convenient to plot some of interrelated values together against the samples instead of plotting them individually e.g., Ca^{2+}, Mg^{2+} & total hardness of the samples.

Table-2
Average results of the physicochemical and microbiological parameters of different sites in Kallar Syedan

Parameters	SP-1	SP-2	SP-3	SP-4	SP-5	WHO (1973)	ISI 10500-91
pH	7.09	6.74	7.25	7.25	7.49	7-8.5	6.5-8.5
EC	1320	2390	2325	385	410	1400	-
TDS	560	1200	1400	395	485	1000	500
Turbidity	0.1	0.2	0.4	0.4	2.5	5	10
DO	2.0	2.1	2.4	8.2	8.5	-	5.0
TA	324	540	520	280	180	120	200
Mg^{2+}	57	86	120	75	135	150	30
Ca^{2+}	98	65	99	45	100	100	75
TH	155	351	319	120	235	500	300
Na^{+}	285	237.65	372.45	37.87	55.89	200	200
K^{+}	0.234	0.785	1.598	2.653	3.675	-	-
Cl^{-}	165.78	234.89	311.90	20.87	45.34	250	250
NO_3^{-}	0.056	0.872	0.654	1.643	0.076	5	45
SO_4^{2-}	27.67	43.89	89.76	22.98	21.67	250	200
PO_4^{3-}	0.155	0.234	0.437	0.253	0.155	-	-
COD	8.5	10.5	10.8	5.5	11.0	10	-
MPN/100 ml Coliforms	1	7	10	0	5	0	-

pH: pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. Most of the waters are slightly alkaline due to presence of carbonates and bicarbonates. The pH values of water samples varied between 6.7 to 7.4 and only minor fluctuation in pH was recorded and was found within the limit prescribed by WHO. The pH levels were within the limits set for domestic use as prescribed by APHA[22]. Graphically the pH values for all sampling points are shown in figure-1

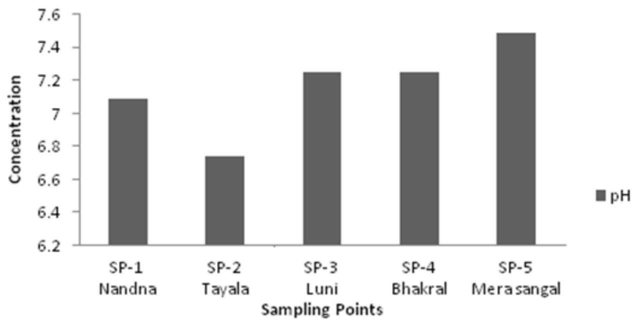

Figure-1
pH values for all sampling points

Electrical Conductivity (EC): Electrical conductivity is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts[23]. The range for EC values was 385 mho/cm to 2390 mho/cm. High EC values were observed for two sampling points SP-2 and SP-3 (one open well, one tube well) indicating the presence of high amount of dissolved inorganic substances in ionized form while SP-1, SP3, SP-4 and SP-5 showed EC value within the range prescribed by WHO as show in figure-2.

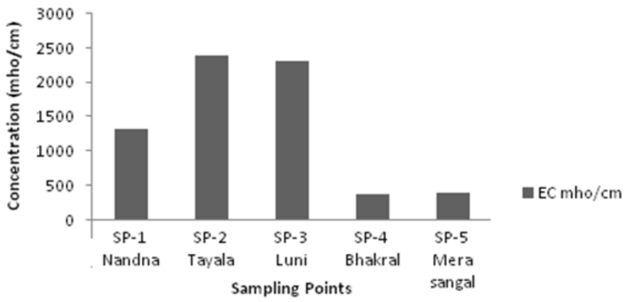

Figure-2
Concentration of EC for all sampling points

Total dissolved solids (TDS): Total dissolved solids indicate the salinity behavior of groundwater. Water containing more than 500 mg/L of TDS is not considered desirable for drinking water supplies, but in unavoidable cases 1500 mg/L is also allowed[24]. The TDS concentration is considered a secondary drinking water standard, which means that it is not a health hazard. However, water with a high TDS concentration may indicate elevated levels of ions that do pose a health concern, such as aluminum, arsenic, copper, lead, nitrate, and others. TDS values varied from 395 mg/L to 1400 mg/L. The sampling points SP-1, SP-2 and SP-3 showed higher TDS values than the prescribed limit given by ISI 10500-9 1. However in the SP-5, the TDS value (485 mg/L) is about to reach the maximum permissible while TDS value for SP-4 is within the prescribed limit (395 mg/L) given by ISI 10500-9 1. The graphical representation is shown in figure-3. These values are acceptable for domestic use and agricultural purposes.

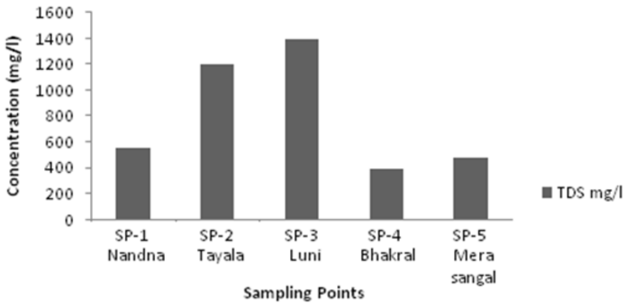

Figure-3
Concentration of TDS for all sampling points

Turbidity: In most waters, turbidity is due to colloidal and extremely fine dispersions. The turbidity values for SP-1, SP-2, SP-3 and SP-4 were 0.1, 0.2, 0.4 and o.4 NTU respectively whereas for SP-5 (2.5 NTU), it is slightly higher than other sampling points but all the sampling points showed turbidity within the limits prescribed by ISI 10500-91 and WHO as shown in figure-4. Deterioration in drinking water quality in distribution networks is probably due to an increase in microbial numbers, an elevated concentration of iron or increased turbidity, all of which affect taste, odor, and color in the drinking water. Turbidity can provide shelter for opportunistic microorganisms and pathogens[25].

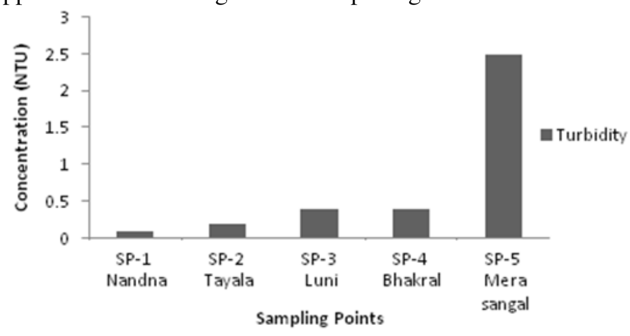

Figure-4
Concentration of Turbidity for all sampling points

Dissolved oxygen (DO): Dissolved oxygen is important parameter in water quality assessment and reflects the physical and biological processes prevailing in the water. The DO values indicate the degree of pollution in water bodies. DO values varied from 2.0 to 8.5 mg/l. The sampling points SP-1, SP-2 and SP3 showed low DO values (2.0, 2.1 and 2.4 mg/L) respectively whereas SP-4 and SP-5 showed higher DO values (8.2 and 8.5 mg/L) respectively indicating heavy contamination by organic matter. Graphically the values of DO for all sampling points are shown in figure-5.

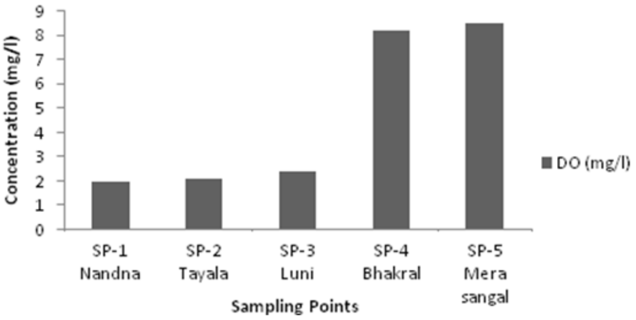

Figure-5
Concentration of DO for all sampling points

Chemical Oxygen Demand (COD): Chemical oxygen demand (COD) is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers), making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution. The maximum allowed value of chemical oxygen demand (COD) is 10 mg/L in drinking water. The present samples have registered a range of 9.5 to 14.6 mg/L as shown in figure-6. These values are little higher than that expected for a good quality potable water. However, the higher values of COD were observed only in SP-5 taken from municipal water supply. The most probable reason for this slightly higher value of COD may be due to leakage of water supply line and sewage discharge.

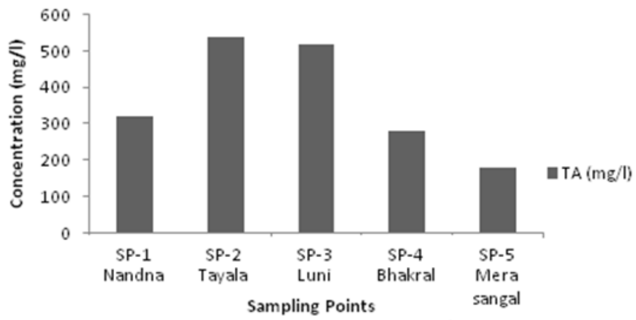

Figure-6
Concentration of COD for all sampling points

Total Alkalinity: Total alkalinity of water is due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium and it is capacity to neutralize a strong acid. The prescribed value for total alkalinity by WHO is 120 mg/L and by ISO-10500-91, its value is 200 mg/L. Total alkalinity values for all the investigated samples SP-1 to SP-5 were found to be greater than the value prescribed by WHO as shown by figure-7.

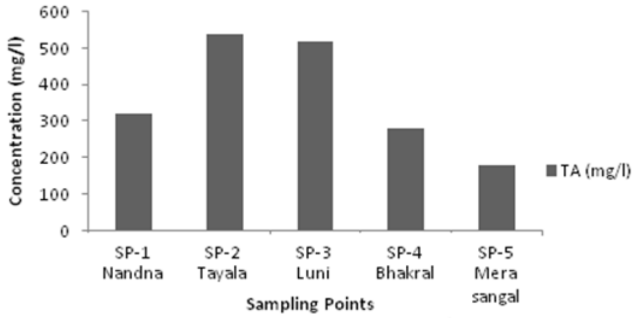

Figure-7
Concentration of Total Alkalinity for all sampling points

Calcium and magnesium (Ca^{2+}, Mg^{2+}): Calcium and Magnesium are directly related to hardness. Calcium concentration ranged between 45 mg/L to 100 mg/L and found below permissible limit, except municipal water supply sample from sampling point SP-5 which was exactly equal to the prescribed limit by WHO (100 mg/l). Magnesium content in the investigated water samples from SP-1 to SP-5 was ranging from 57 mg/L to 135 mg/L which were found within WHO limit as shown in figure-8.

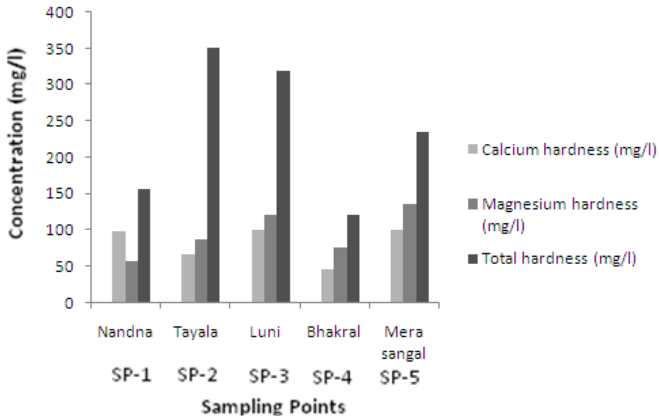

Figure-8
Concentration of Total Hardness for all sampling points

Total hardness (TH): Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water[19]. Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. The hardness values showed range from 120 mg/L to 235 mg/L which are within the prescribed limit by WHO as shown in Figure-8.

Sodium (Na^{+}): Sodium concentrations were found in between 37.87mg/L to 372.45 mg/L. Two tube well sampling sites SP-1 and SP-2 (285, 237.65 mg/L) and one open well sampling site SP-3 (372.45) showed higher sodium concentration than the prescribed limit whereas SP-4 and SP-5 showed values within the limit prescribed by WHO.

Potassium (K^+): The major source of potassium in natural fresh water is weathering of rocks but the quantities increase in the polluted water due to disposal of waste water[19]. Potassium content in the water samples varied from 0.234 mg/L to 3.675 mg/L.

Chloride (Cl^-): The chloride concentration serves as an indicator of pollution by sewage. People accustomed to higher chloride in water are subjected to laxative effects[23]. In the present analysis, chloride concentration was found in the range of 20.87 mg/L to 311.90 mg/L. The values are within the limit except water sample collected from sites SP-2 and SP-3. Higher chloride concentration in samples from sites SP-2 and SP-3 may be due to huge discharge of sewage near the sampling sites. The graphical representation of Na^+, K^+ and Cl^- concentrations for all sampling points is shown in figure-9.

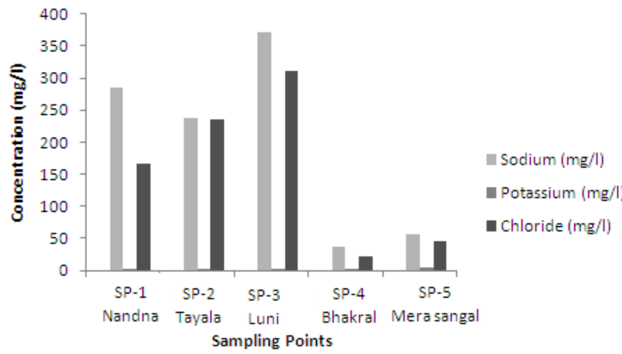

Figure-9
Concentration of Na^+, K^+, Cl^- for all sampling points

Nitrate (NO_3^-): Groundwater can be contaminated by sewage and other wastes rich in nitrates. Groundwater contains nitrate due to leaching of nitrate with the percolating water. The nitrate content in the study area varied in the range 0.056 mg/L to 1.643 mg/L and found within the prescribed limit given by WHO and ISI 10500-91.

Sulphate ($SO4^{2-}$): Sulphate occurs naturally in water as a result of leaching from gypsum and other common minerals[20]. Discharge of industrial wastes and domestic sewage tends to increase its concentration. The sulphate concentration varied between 21.67 mg/L and 89.76 mg/L. and found within the prescribed limit.

Phosphate ($PO4^{3-}$): Phosphate may occur in groundwater as a result of domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste water. The phosphate content in the study area was found in the range of 0.155 mg/L to 0.473 mg/L.

The graphical representation of NO_3^-, SO_4^{2-} and PO_4^{3-} concentrations for all sampling points is shown in figure-10.

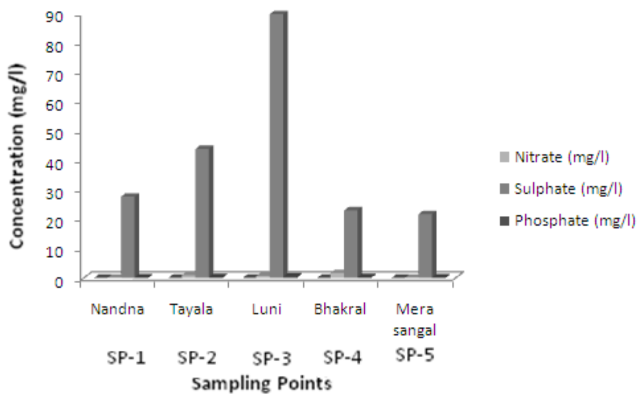

Figure-10
Concentration of NO_3^-, SO_4^{2-}, PO_4^{3-} for all sampling points

Bacterial Count (MPN/100ml): The most probable number is a suitable and most widely used method to determine the microbial quality of water. Present investigations have rendered the values of 0-10 MPN coliforms/100 ml of water which exceed the permissible limit of WHO (0 coliforms/ 100 ml). Municipal water supply sample SP-5 showed 5 MPN/100ml that exceeds the limit prescribed by WHO showing contain significant amount of organic matter that provides nutrition for the growth and multiplication of microorganisms. This was mainly due to the leakage of underground water supply line and sewage discharge. SP-2 (tube well) and SP-3 (open well) also showed high level of pathogen indicator (7-10 MPN/100ml) respectively. This was mainly due to huge sewage dump near these sampling points whereas SP-1 and SP-4 showed coliform number within the limits prescribed by WHO as shown in figure-11.

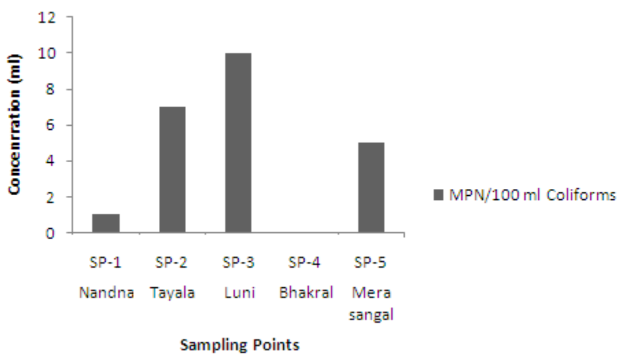

Figure-11
Concentration of Coliforms MPN/100ml for all sampling points

Conclusions

Deviations were observed by groundwater samples from municipal water and water quality standards indicating groundwater pollution. Municipal water contained fecal coliforms mainly due to leakage of pipe line. The water samples from sites SP-2 (tube well) and SP-3 (open well) showed poor water quality as compared to other water samples, probably due to sewage pond close to site SP-2 and large sewage flowing near the site SP-3. The water samples from sites SP-2 and SP-3 are highly polluted and unfit for drinking purpose. The sampling point SP-1 (tube well water) showed high TDS, alkalinity and sodium content indicating the need of some treatment for minimization of the parameters. The sampling site SP-4 (open well) showed physico-chemical parameters within the water quality standards and the quality of water is good and it is fit for drinking purpose.

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