Impact of Drinking, Surface and Underground Water on Urolithiasis

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Summary: Sixty two drinking water samples (39 from underground and 23 from surface water sources) from six districts of Sindh were chemically analysed for pH, sodium, potassium, calcium, magnesium, phosphate and silicate contents. Samples from the same sources were also analysed for total bacterial count and total and differential coliform densities. Results show that the total alkalinity, total hardness and mineral contents of underground waters were significantly ($P<0.001$) higher than the surface waters while reverse was true for the pH and phosphate. Surface water was also found to be highly contaminated by faecal coliforms. Although no direct relationship between microbial contamination of surface water and urinary stone disease was observed, low calcium intake alongwith increased ingestion and excretion of oxalate and phosphate due to faulty dietary habits might be a possible cause of higher incidence of urolithiasis in surface water users.

Introduction

Since people in the developing countries drink unchlorinated and untreated water [1], prevalence of many communicable diseases may be associated with this polluted water. Some 4,600,000 children under the age of five and some two million people die every year of diarrhoea and malaria, respectively [2]. Also dehydration secondary to an attack of malaria or following an acute diarrhoea and vomiting has been attributed to urinary stone formation [3,4]. Practically, all natural waters contain dissolved minerals and definitely exert significant effect not only on potability and palatability of drinking water but also influence the human health [5]. The greater danger associated with drinking water has been its contamination with sewage or excreta from human or animals [6,7] and this results in outbreaks of many complications. The incidence of urolithiasis varies widely in different parts of the world and this may be caused by dietary and climatic variations or due to some other factors [8,9]. The finding of Rose and Westbury [10] revealed a relationship of urolithiasis with soft water supporting the results of Mates [11] and contradicting the old historical belief of hard water and renal calculi relationship. Most population based studies from Newfoundland [12] and Sweden [13], also show no relationship between the hardness of drinking water and stone prevalence. Conversely, negative correlation has been found in the United States [14,15], the Great Britain [10,16] and Ireland [17]. Unfortunately, no such studies have so far been reported for Pakistan. In an epidemiological survey (unpublished data) we found that majority of our population including urolithiatic patients consume surface later than underground water.

The present study, therefore, was undertaken to elucidate the role of drinking surface and underground water in the pathogenesis of urinary stones with respect to their chemical and microbial contents.

Results and Discussion

The details of the chemical analyses of water samples obtained from different sources of the six districts is given in Table 1. The data shows that water from these sources varied in pH. The highest pH (7.9) was noted for canal water while lowest for hand pump and it was nearly neutral. The mean total alkalinity of these samples ranged from 90.6 to 308.7 mg $CaCO_3$/L whereas, total hardness and non-carbonate hardness, N-C.H (which is the hardness of water exceeding total alkalinity) was between 114.85 and 336.13 and 24.10 and 55.44 mg $CaCO_3$/L respectively. Lower values of alkalinity and hardness were found in canal water whereas the highest in well water. The N-C. H levels were lower in hand pump water and higher in motor pump.

Table 1: Chemical differences (Mean ± 1 SEM) in the water from various sources.

Parameter	pH	T.A as mg $CaCO_3$/L	T.H as mg $CaCO_3$/L	N-C.H as mg $CaCO_3$/L	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	P µg/L	SiO_2 mg/L
Handpump (26)	7.35 (± 0.05)	303.15 (± 18.88)	277.15 (± 16.04)	8.14 (± 2.95)	160.47 (± 36.34)	19.20 (± 6.70)	62.13 (± 5.07)	28.80 (± 2.63)	21.69 (± 3.82)	27.73 (± 1.58)
Motorpump (06)	7.60 (± 0.10)	281.40 (± 24.94)	292.07 (± 38.93)	55.44 (± 18.15)	175.67 (± 48.01)	6.82 (± 1.36)	61.54 (± 13.77)	33.45 (± 5.25)	43.07 (± 10.13)	29.62 (± 3.62)
Well (07)	7.62 (± 0.12)	308.70 (± 37.83)	336.13 (± 37.30)	41.88 (± 17.62)	199.40 (± 68.53)	24.52 (± 9.07)	73.10 (± 12.62)	36.05 (± 3.97)	30.59 (± 8.15)	24.06 (± 5.14)
Tapwater (16)	7.87 (± 0.05)	101.69 (± 3.28)	127.45 (± 11.24)	27.74 (± 9.90)	31.34 (± 9.22)	4.87 (± 0.33)	31.90 (± 2.89)	10.74 (± 1.70)	49.16 (± 7.44)	10.12 (± 1.01)
Canal water (07)	7.94 (± 0.04)	90.60 (± 2.38)	114.85 (± 12.79)	24.10 (± 11.15)	21.52 (± 3.68)	5.36 (± 0.53)	31.30 (± 3.03)	8.49 (± 1.22)	125.69 (± 29.0)	9.57 (± 0.89)
F. Value	14.77	25.25	17.79	3.42	3.46	1.49	6.51	13.02	12.10	17.06
Level of significance	< 0.01	<0.01	<0.01	<0.05	<0.05	N.S	<0.01	<0.01	<0.01	<0.01

( ) indicates number of samples. T.A. = Total alkalinity, T.H. Total hardness, N-C.H. = Non-carbonate hardness, N.S. = Non significant.

Among the minerals the mean values for calcium and magnesium were significantly lower in tap and canal waters than hand pump and well waters. The maximum levels of both the elements (73.10 and 36.05) were found in well water while canal water showed the lowest (31.30 and 8.49) values, respectively. The contents of sodium and potassium showed similar pattern. The concentration of phosphate (as orthophosphate) ranged between 21.69 (Hand pump) to 125.69 µg/L (surprisingly in canal water). The silicates (as SiO_2) showed the highest level (29.62 mg/L) in motor pump water and the lowest (9.57) was recorded in canal water.

When compared statistically (Table 2), all the constituents of the water (except N-C.H and K) present in underground sources (hand pump, motor pump and wells) differed significantly ($P < 0.001$) to that of surface water (tap and canal).

All water samples were found to contain various microbial species. Total bacterial and coliform counts were noted to be maximum in canal water (Mean 54×10^3 and 110 respectively), followed by tap (37×10^3 and 62 respectively), well (11×10^2 and 11 respectively), and hand pump (9×10^2 and 2 respectively) waters. Samples obtained from large sized earthenware pitchers (used to store bulk of water to be used frequently as in hotels or other public places) were found to be highly contaminated (Mean 35×10^3 and 73 respectively), irrespective of their source.

Table 2: Overall comparison of the chemical constituents (Mean ± SEM) of underground and surface waters.

Chemical constituent	Underground waters n = 39	Surface waters n = 23
pH	7.44 ± 0.05	7.89 ± 0.03*
T.A	300.8 ± 14.9*	98.3 ± 2.6
T.H	290.03 ± 14.41*	123.61 ± 8.82
N-C.H	21.47 ± 5.46	26.63 ± 7.69
Na	169.79 ± 28.26*	28.35 ± 6.57
K	18.26 ± 4.83	5.02 ± 0.28
Ca	64.01 ± 4.63*	31.72 ± 2.21
Mg	30.84 ± 2.11*	10.01 ± 1.26
P	26.58 ± 3.55	72.45 ± 12.59*
SiO_2	27.36 ± 1.53*	9.95 ± 0.75

P <0.001

Some investigators believe that urinary stone formation is caused by type of water in the area. Since the quality of water differs according to geographic and climatic conditions [25], the analysis of quality drinking water, being used by the local inhabitants of six districts (mainly Hyderabad, Sindh, which had been claimed as the second highest lithiatic area after D.G. Khan, in the subcontinent) [26] was carried out. The data about the chemical constituents of drinking water samples, obtained from different sources, show that except pH and phosphate, all the variables (total alkalinity, hardness and mineral contents) were significantly higher in underground than surface waters. Though, the pH of surface water was significantly

higher than the underground, it was never beyond the limits permitted by WHO [7], while, the increased content of phosphate might have a link with the frequent use of phosphate containing fertilizer and the soil itself.

In the epidemiological survey (unpublished data) we noticed that 69 per cent of the lithiatic patients have been consuming surface water (39.3% water supply, 28% canal and 1.4 % pond water) and the rest underground. Although, the total hardness of surface (soft) drinking water was comparable to the data reported by Okumara [27] for Karachi and Islamabad, the higher incidence of urolithiasis in surface water users of Hyderabad and its adjoining areas is really deplorable.

Our finding that Ca levels of all drinking water samples were below the desired levels of 75 mg/L [28], being significantly lower in surface waters than underground, suggests that the reduced content of Ca might be one of the contributing factors towards urolithiasis [29]. Since, our previous results [30,31] confirm Ca as a principal element alongwith oxalate and phosphate, the genesis of such stones seems to appear due to excessive excretions of oxalates and phosphates but not the calcium alone.

The detection of sufficient number of total bacteria (especially coliforms) in all water samples provides good evidence of microbial contamination at the source, between the source and storage place [32]. Our results clearly demonstrate that surface water is highly contaminated than underground and therefore, is likely to favour the water borne diseases [33] and/or carbonate- apatite and magnesium ammonium phosphate type calculogenesis [34].

However, our failure to get pure Mag.Amm. Phosphate (infection)stone from patients and the presence of Amm. urate only in the central cores of children's (0-14 years) bladder stones [30,31] suggests that there seems no direct association between infection and urolithiasis in surface water drinkers.

Since, formation of stones in urinary tract seems to be a complication of varied metabolic disorders [35], it may be concluded that increased incidence of urolithogenesis in surface water users could be due to dehydration (secondary to excessive gastrointestinal disturbances) and increased excretions of oxalate and phosphate (owing to decreased intake of calcium and/or faulty dietary habits of the people in this area), which is open for further investigation.

Experimental

62 drinking water samples from different sources (23 surface and 39 underground) were collected at random from various locations of six districts of Sindh (Hyderabad, Badin, Tharparkar, Nawabshah, Dadu and Khairpur) according to WHO criteria [18]. All the samples were collected in a day time in 1000-ml screw caped dried plastic bottles, sequentially cleaned according to Meranger *et al.*, [19]. Each bottle was filled to the brim with the sample to avoid any air space, tightly caped and labelled. In case of tap water samples, the taps were run at their maximum for 2-3 minutes before collection. Most of the samples were collected from those sources which were being actually used by the inhabitants of that area.

Chemical studies

pH, total alkalinity and total hardness were determined using the techniques described by Lind [20]. All these determinations were carried out on the day of the collection and afterwards nitric acid (conc.) was added into the water samples to avoid metal losses [21]. The levels of Na and K were detected by flame photometry and of Ca and Mg by atomic absorption method [22]. For orthophosphate a modified method of Murphy and Riley [23] and for silica Lind's method [20] were followed.

Microbial studies

A total of 33 (10 hand pump, 3 open well, 3 tap, 4 canal, and 13 reservior and clayware) water samples were aseptically collected in pre-sterilized 500-ml glass bottles from the same locations.

Every care was taken to prevent the contamination of the stopper from hands and any other source. All the samples thus collected were immediately transported to the laboratory and processed within 1-2 hours and tests were carried out for total bacterial count, total coliform count and differential densities of coliforms and other organisms.

Total bacterial count was performed after 10-fold dilution of the samples. After incubation, number of positive replications were noted and most probable number (MPN) was computed [24]. Total coliform density and differential density tests were carried out by membrane filter (MF) technique [22] i.e., after passing the water samples through presterilized membranes (Whatman 0.45 um) under vacuum pressure, the membranes were incubated on different nutrient agars (Merck) and the colonies grown were counted under the Coloney Counter (Gallenkamp 220-240 volts). The identification of different bacteria was confirmed with api Strep and api Staph kits.

Statistical analysis

For comparison of chemical differences in the water from different sources ANOVA test was used. For comparisons between surface - and underground - waters, Student's t-test was used.

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