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An Assessment of Relationship Between Arsenic in Drinking Water, Health Status and Intellectual Functioning of Children in District Kasur

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Abstract: In this study determination of arsenic (As) contamination in the drinking water and urine of children along with its effect on their health status and intellectual functioning was assessed. The study was carried out in order to determine any correlation between intake of arsenic and intellectual functioning level of the children. Raven Standard Progressive Matrices (RPM) was administered on children of (8-15) years of age to assess their intellectual functioning and their health status was checked by measuring their height and weight. Water and urine sample were studied in both experimental and control group. In experimental area Arsenic level was above the World Health Organization (WHO) permissible value which was compared with control area having arsenic level below WHO permissible value in both water and urine. An average 45% of arsenic level in drinking water samples was above WHO permissible value (10 µg/L). Considering urinary arsenic as a biomarker of exposure to arsenic through drinking water, it was found that an average of 50% of children of the experimental group were found to have arsenic in their urine ranging from a concentration of 0.01-0.0119 µg/L. Conclusively, this study showed that the intellectual functioning level of children drinking arsenic contaminated water was significantly lower as compared to those, drinking arsenic-free water.

Key words: Arsenic, water, health, intellectual functioning, tanneries waste, urine

INTRODUCTION

Arsenic is a naturally occurring substance that ranks 12th in abundance in the earth's crust, 14th in the seawater and 12th in the human body (Naqvi, 1994). Exposure to this element has many chronic and acute health effects The WHO permissible limit of Arsenic in drinking water is 10 µg/l (WHO, 1993) and the same value is followed in Pakistan. Arsenic is a natural element found on earth as it is usually called the "king of poisons". In the past Arsenic was used to treat Syphilis (Wilson, 2001).

In the past it was used as a beauty enhancing agent, as Victorian women used to rub it on their bodies or engulf it in order to have a paler complexion but such beauty tips had harmful effects on human health causing various ailments (Lapinski, 2005). Human exposure to inorganic As is common due to its natural existence in underground water, especially in Bangladesh and India, but its high level in ground water is due to its extensive use in industries (Das *et al*., 1994).

Current study was conducted on Kasur tanneries area where arsenic is used for dyeing process. Tanneries in Kasur on an average, process over 180 tons of wet salted hides (cattle, buffalos) and 15 tons of skins (sheep and goat) per day. Alarming levels of As, Cd, Hg, Ni and Cr-VI were noted not only in raw tannery waste, but also in underground water near tannery industry. According to the WHO 1993 Guidelines for drinking water, these heavy metals have a serious effect on public health when they enter the water or food chain (WHO, 1993).

After ingestion both organic and inorganic form of Arsenic readily absorb into the blood from the gastrointestinal tract. First, the pentavalent inorganic form of As (arsenate) is changed to trivalent form (arsenite) then it goes to liver where it is detoxified through methylation process. Methylation involves stepwise conversion of As to Monomethyl Arsonic Acid (MMA) and then to Dimethylarsinic Acid (DMA) by an enzyme methyl transferase (Healy *et al*., 1999). These end products are readily released in urine (Tice *et al*., 1997).

Raven's Progressive Matrices (simply as Raven's Matrices) are normally used to measure the intellectual functioning level of a person. It consists of MCQ (Multiple choice questions) of abstract reasoning, originally introduced by John Raven (1936). In each test item, an individual is given a task to identify the missing segment required to complete a particular larger pattern. This test is used in measuring intellectual functioning (Raven, 1936).

This study was conducted to determine the prevalence of arsenic contamination in the drinking water sources in the suburban areas Kasur city and to find out the concentration of arsenic in drinking water and urine of children along with its effects on intellectual functions of the same children.

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MATERIALS AND METHODS

It was community based cross sectional-descriptive type of study conducted in three villages of Kasur city, approximately 55 kilometer in the east of city of Lahore, Pakistan. Study population includes: All the people most probably school going children living in three villages; Bangalacombo (site I), Kamal Chisti Town (site II), Qaser Ghar (site III) and household potable water supply sources in the same area.

Adults and children who could understand the questions and living in the area for more than 5 years were selected for the sampling. Those people who had migrated to the target area recently i.e. in last 5 years or those who were not staying there on permanent basis were excluded. Drinking water and urine samples were collected in bottles from all the three sites. Names and addresses of study persons were mentioned on sample bottles to avoid mixing. Water and urine samples were preserved at 4^{0}C after acidifying with concentrated nitric acid (HNO_3) at 2 pH and filtered for dissolved metals before preservation. The main idea behind addition of (HNO_3) in water and urine sample was to maintain pH of samples. Water and urine sample were collected from both experimental and control group. Arsenic value in urine and water was determined with the help of Atomic Absorption Spectrophotometeric (AAS, Nova 60 of Merck) method. Raven's Progressive Matrices (RPM) was applied to measure the intellectual functioning of children (Raven, 1956) to overcome poor response on the basis of cultural bias. The Raven's Progressive Method has been used in many studies related to assessment of intellectual functioning. Children were allowed to sit in a silent room where they were provided with pencils to attempt task. They were only allowed to sit at a particular distance so that they didn't copy each other and their score was calculated (Ali *et al*., 2007; Nejat *et al*., 2007; Kang *et al*., 2007).

Sample population was divided into intellectually superior (above the 95th percentile), definitely above the average in intellectual capacity (above the 75th percentile), intellectually average (between the 25th and 75th percentiles), definitely below average in intellectual capacity (at or below the 25th percentile) and intellectually defective (at or below the 5th percentile) for their age-groups.

RESULTS AND DISCUSSION

Comparison of socioeconomic status of people was assessed through a questionnaire, conducted in sties I, II and III, hit by arsenic contamination (experimental group) and in site where arsenic (in potable water) was not detected (control group), that is shown in Fig. 1 and 2. There were more literate people in control group (Fig. 1) and less in experimental group while the monthly income (Fig. 2) correspond to the literacy rate, being higher in control group than the experimental group. The income of only 35% of experimental group was between Rs. 7001-12000 and a majority (59%) was placed in lowest income group i.e. Rs. 3000-5000. In comparison 46% of the control earned between Rs. 7001-12000.

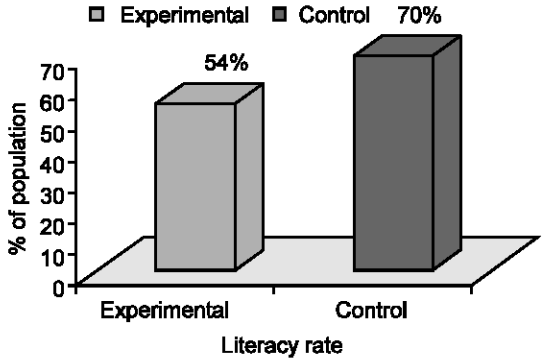

Fig. 1: Comparison of literacy rate of parents in experimental and control group

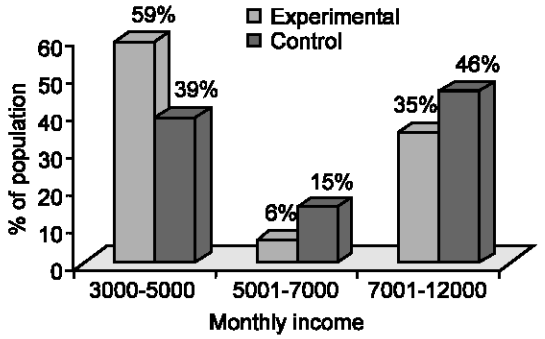

Fig. 2: Comparison of monthly income among in experimental and control group

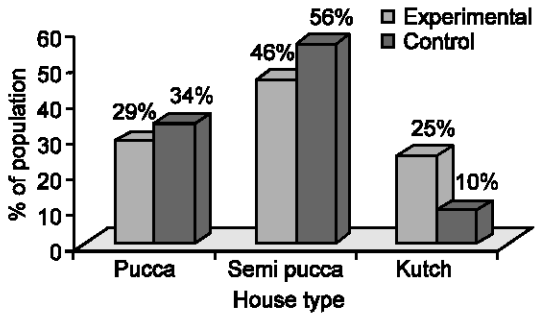

Fig. 3: Comparison of types of houses in experimental and control group

One of the parameters for assessing the standard of living was the type of houses (Fig. 3) Majority in control group had pucca (made up of bricks) and semi pucca houses in comparison to experimental group. It means that people in control group, where drinking water was better and were living in better conditions as compared to experimental group. As far as the provision of water supply was concerned there was not much difference between the experimental and control group, as 57% of

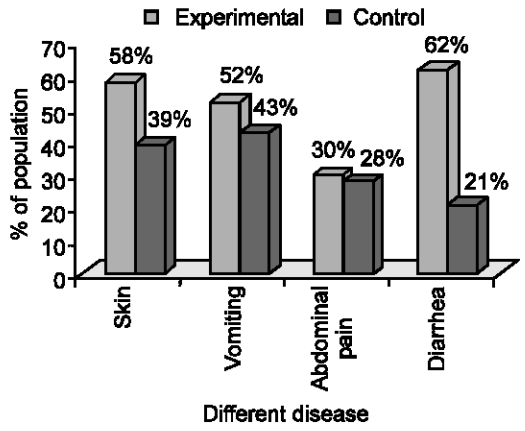

Fig. 4: Comparison of different diseases among children in experimental and control group

the latter and 60% of the former drew water by hand pumps. Similarly 42% of the control and 34% of the experimental group respectively got water from municipal supply. Wasserman *et al.* (2006) revealed better scores among children who a) had more educated mothers; b) lived in more adequate dwellings; c) had access to television; d) were taller and e) had a larger head circumference.

Comparison of depth of water sources in both experimental and control group on the basis of data collected from district government Kasur showed that majority of people in these groups were drawing water from less than 200 meters. About 54% of people in control and 40% in experimental group drew their drinking water at the depth of 101-200 meter. In experimental and control group 82% and 39% of the population was reporting turbidity in the drinking water respectively.

From Figure 4, it can be observed that higher percentage of children residing in the three target sites suffered from disease as compared to those living in the control area. Diarrhea (62%), vomiting (52%) and skin problems (58%) were the diseases generally more prevalent indicating that the absence of arsenic in drinking water led to higher intellectual functioning value.

Percentage of arsenic detected in water (using Field Kit and AAS) and urine (using AAS) is shown in Table 1. Arsenic detection in drinking water samples using arsenic field kit and Atomic Absorption Spectrophotometer (Table 1) revealed that arsenic was detected in 41, 56, 35% of water samples in site I, II and III respectively with field kit and 47, 56, 35% in Site I, II and III respectively with ASS. Von Ehrenstein *et al.* (2007) measured arsenic concentrations in urine and peak water was slightly higher in boys (urine, 87 µg/L; water, 157 µg/L) than in girls (urine, 68 µg/L; water, 136 µg/L) but in this study gender difference was not considerable. Water samples collected from site II showed greater number of arsenic concentration. Results for arsenic detection in urine by AAS were parallel to those of water

Table 1: Percentage of arsenic detection in excess of permissible limits of water (using Field kit and AAS) and urine (using AAS) in experimental group

	Percentage of Arsenic in drinking water		Urine
	Field Kit	AAS	AAS
I	41%	47%	41%
II	56%	56%	43%
III	35%	35%	29%
Average	44%	46%	37.66%

Table 2: ANOVA between groups for weight, height and percentile score of intellectual functioning

SOV	SS	df	MS	F	p-value	Fcrit
[1]Groups	88.167	1	88.167	75.57	0.0129	18.51
[2]Variables	1542.300	2	771.170	661.00	0.0015	19.00

[1](Experiment and control), [2](Weight, height and percentile score of intellectual functioning), SS = Sum of Square, df = Degree of freedom, MS = Mean Square, P = Probability, F = F-Distribution value, Fcrit = Critical value of F, SOV = Source of Variation

Table 3: T-test for height, weight, total score and percentile score of intellectual functioning between experimental and control groups at 0.05 level of significance, 78 degree of freedom and 1.98 table value of T

Variables	Standard deviation	T-value calculated
Height	4.21	10.77
Weight	6.08	11.56
Total score	10.60	3.57
Percentile score	15.93	4.04

Table 4: Relation between average age, weight and height of children with intellectual functioning level in experimental and control group

				IF	
Area	Age (Years)	Weight (kg)	Height (Inches)	TS	PS
Site I	12	35	51	23	17
Site II	13	36	54	23	10
Site III	11	34	49	22	15
Control	12	45	60	26	20

IF = Intellectual Functioning, TS = Total Score, PS = Percentile Score

samples, showing maximum number of contamination in population living in site II. Arsenic was not detected in the water and urine samples, taken from population of control group. This study also provided an opportunity to make a comparison of the results of detection of arsenic by Field Kit method and Atomic Absorption Spectroscopy. Table 2 and 3 showed the significant difference between control and experimental groups. This difference in values of experimental and control is due to the difference of arsenic level in water. F-value is greater than Fcrit so there is a significant difference between experimental and control groups.

The relationship between health status and intellectual functioning is shown in Table 4. Table indicates that in comparison to control group, in all three sites the average height and weight of children is lower so is the intellectual functioning level, which clearly shows the relationship of health status with their intellectual functioning level. The same table also shows that the

average age of children in Site II is thirteen years as compared to twelve in control site but not only their average height and weight is lower but their average intellectual function level is fifty percent less than that of a control area.

Conclusion: In the present study arsenic was detected in three villages of Kasur city, approximately 55 kilometer in the east of city of Lahore. Statistical analysis showed that there was a significant difference between experimental and control groups. Overall results showed that urinary arsenic concentrations, a biomarker of exposure to inorganic arsenic in drinking water, was correlated with poor health status of children consuming arsenic contaminated water. Moreover, arsenic intake from drinking water was correlated with childhood intelligence measured on the basis of intellectual functioning using Raven's Progressive Method. Lower intellectual functioning level of children consuming drinking water contaminated with arsenic, are clearly indicative of its detrimental effect on their intellect.

Recommendations: In the light of above mentioned results following recommendation are made:

City District Government along with Environmental Protection Department should survey the tannering processes of drying and dying.

Tanneries operator should be encouraged to use cleaner techniques and ordered to stop discharging effluents of their factories into domestic sewage system as it is used in agricultural fields.

People in the study area should be provided with safe water along with supply of safe food stuff.

People should be made aware of this health hazard by public health awareness and education programs. These programs should be made with the involvement of local people followed by a series of local group discussions.

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