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Suffering water of Pakistan: arsenic – A major threat

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Arsenic which is known as 'Sinkhia' in Pakistan is notorious as a king of poisons. It is commonly found in water, mostly originating from geological sources and pollutes the environment. It is the 12th most common element in nature. It can be found in the earths' crust, atmosphere, rocks, soil, organisms and natural water. Studies show that 60% of the arsenic is introduced into the atmosphere by anthropogenic activities. It can combine with other elements to form inorganic and organic arsenic compounds. The important inorganic species are arsenate (As V) and arsenite (As III). Inorganic arsenic compounds may include oxygen, sodium, copper, potassium, chlorine, sulphur and iron, while arsenic combines with carbon and hydrogen to form organic arsenic in plants and animals. The three basic pathways of arsenic or sources of ingested arsenic include, water, food (fish, sea food, cereals and algae) and air (smelting, coal-fired power generation). Out of these sources long term exposure to arsenic in drinking water is the greatest threat to human health. Because of daily and widespread consumption, the presence of arsenic in drinking water has been documented as a major public health concern in many parts of the world in recent years. The worst health effects due to arsenic are directly related to the dose and duration of exposure. Dermatological effects are the characteristics of chronic or severe exposure to arsenic. The dermatological effects include Melanosis (pigmentation) and Keratosis (rough, dry skin lesions) which may be spotted or diffuse. Arsenic's chronic exposure may result in neurological, reproductive, cardiovascular, haematological, respiratory and diabetic effects in humans. Like other parts of the world in Pakistan too, people are exposed to arsenic by different ways like by the intake of contaminated water or food, by the use of arsenic containing medicinal preparations, by inhalation or by homicidal or suicidal ingestion of arsenic compounds. Data regarding arsenic contamination in drinking water is lacking in Pakistan. It is essential that strategies are made available to tackle the health hazards caused by arsenic contaminated water. This review is an attempt to cover the available data concerning arsenic contamination, particularly in Punjab and Sindh and generally in Pakistan.

Key words: Arsenic hazards, contaminated drinking water, Arsenic in Pakistan

ARSENIC – THE HISTORY

Arsenic has been derived from the Greek word "Arsenikon" which means 'Yellow Orpiment' [1]. It was first discovered by Albertus Magnus in 1250. Arsenic is a metalloid existing in more than 200 different forms whereby 60% are arsenates, 20% sulphosalts, sulphides and arsenite, oxides, arsenide, silicates and elemental arsenic constituting the remaining 20%, which exhibit different grades of toxicity [2]. Arsenic which is known as 'Sinkhia' in Pakistan is notorious as a king of poisons. It is commonly found in water, mostly originating from geological sources and pollutes the environment [3]. It is the 12th most common element in nature. It can be found in the earth crust, atmosphere, rocks, soils, organisms and natural water. Studies show that 60% of arsenic is introduced into atmosphere by anthropogenic activities. It can combine with other elements to form inorganic and organic arsenic compounds [4]. The important inorganic species are arsenate (As V) and arsenite (As III) [1]. Inorganic arsenic compounds may include oxygen, sodium, copper, potassium, chlorine, sulphur and iron, while arsenic combines with carbon and hydrogen to form organic arsenic in plants and animals. Organic arsenic present in foods is harmless and easily removed from the body but inorganic arsenic is very toxic and can result in acute, sub-acute or chronic affects. Due to long term exposure it can be deposited in the body and once concentrated it can cause long term damage [2].

SOURCES OF ARSENIC

The three basic pathways of arsenic or sources of ingested As include:

1. Water
2. Food (fish, sea food, cereals and algae)
3. Air (smelting, coal-fired power generation) [5].

Out of these sources long term exposure of arsenic in drinking water is the greatest threat to

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human health. Because of daily and widespread consumption, presence of arsenic in drinking water has been documented as a major public health concern in many parts of world in recent years [6]. Similarly Bangladesh, in recent years, witnessed a mass poisoning of population because of arsenic contaminated ground water [7]. The average concentration of arsenic in sea water may be as high as 2.6 µg/L and in fresh water is nearly 0.4 µg/L [8]. An extreme level of up to 225mg/L, as in the case of drinking well water in Bangladesh can also be reached [9].

ARSENIC – A USEFUL ELEMENT

The initial use of arsenic as a medicine was for curing breathing problems and dates back to around 2500 years ago. Arsenic trioxide (As_2O_3), one of the common forms of arsenic is used in agriculture and for medical purposes such as the treatment of promyelocytic leukemia. During 1970 arsenic was mainly used as an insecticide to kill insects [2].

ARSENIC – A TOXIC, HAZARDOUS CHEMICAL

The worst health effects of arsenic are directly related to the dose and duration of exposure. The dermatological effects are characteristic of chronic or severe exposure to arsenic. The dermatological effects include Melanosis (pigmentation) and Keratosis (rough, dry skin lesions) which may be spotted or diffuse. Chronic exposure to arsenic may result in neurological, reproductive, cardiovascular, haematological, respiratory and diabetic effects in humans [10]. As arsenic is colorless, odorless and tasteless so its exposure is mostly un-noticed especially in drinking water. The International Agency of Research on Cancer (IARC) has classified arsenic as a class I human cancerogen. The skin and many types of intestinal causes like bladder, liver, kidney, prostate and lungs are also linked to arsenic ingestion [5]. A variety of substances coming from different sources can be added to the soil, water, air and the food chain. It can easily accumulate in biological samples such as nails, hair, skin, urine and blood [11]. The nails and hair are considered as the most acceptable biomarkers as arsenic can persist in these biosamples for longer periods of time [12].

DRINKING WATER CRITERIA FOR ARSENIC

The arsenic (As) in drinking water can affect human health and is considered as one of the most important environmental causes of cancer in the world. Thus, it is essential to record the levels of As in the drinking water, its chemical composition and to establish the regulatory standards and guiding principles [13]. According to FAO (Food and Agriculture Organization) the health limit for As in groundwater is 50 µg/L, but in view of recent incidences of As poisoning in the Indian subcontinent, a decrease to 5–10 µg/L is being considered by a number of regulatory bodies throughout the world. The temporary World Health Organization (WHO) guideline for As in drinking water is also 10 µg/L. This is based on the skin cancer risk, which is much higher than the factor usually used to protect human health. However, the WHO states that the health-based drinking water guideline for As should in reality be 0.17 µg/L [14].

Nevertheless, the current drinking water guideline for As adopted by both the WHO and the US EPA is 10 µg/L. This is higher than the proposed Canadian and Australian maximum permissible concentrations of 5 and 7 µg As/L, respectively.

ARSENIC IN PAKISTAN – THE CURRENT SCENARIO

Though a significant proportion of ground water in South Asia is contaminated with arsenic, Pakistan has low levels of arsenic in the ground water as compared to Bangladesh, India and China [15]. The expected increase of population in Pakistan is from 180 million to 221 million by 2025. This represents a threat for the available fresh water supply which is drops from 5600 m^3 to 1000 m^3 per capita. The quality of the water supply in different cities in Pakistan is also deteriorating fast [16]. In Pakistan the screening of water for arsenic contamination started relatively late in the year 2000. It is essential that strategies are built to tackle the health hazards caused by arsenic contaminated water. A record of the data with the arsenic contamination levels in different areas of Pakistan would be helpful to address further contamination [2].

Like other parts of the world in Pakistan too, people are exposed to arsenic by different ways such as by the intake of contaminated water or food, by the use of arsenic containing medications, by inhalation or by homicidal or suicidal ingestion of arsenic compounds. But the arsenic present in the water or food does not evaporate into air [15].

In the Southern part of Sindh, Pakistan 61-73% of the population is facing chronic arsenic toxicity. Almost the same situation prevails in the Punjab province. With a huge outbreak of arsenic contamination in different villages of the Kasur district. The results of the study show that the water

supply schemes of Kasur fail to fulfill the water quality standards and due to the high concentration of arsenic and the people of Kasur face the threat of various diseases like skin cancer, skin irritation and chronic inflammation of the kidneys [16].

Ground water is the main source of drinking water in Pakistan which is pumped out by electric pumps or hand pumps [2]. Another important aspect was revealed in a study which showed, that geographically, more arsenic containing ground water and associated diseases are found along the coastline, suggesting a strong link between arsenic contamination of the ground water and presence of the Arabian Sea. It was found that for the coastal population, the toxicity of arsenic varies with the health of the people, their meal composition, their diet as well as the location of their drinking water storage tanks, overhead or underground. As arsenic is cumulative, its level can be easily determined in hair, urine, nails or skin through which it slowly leaves the body and these studies showed an increasing risk from arsenic in Pakistan [15].

Matiari a district of Sindh, Pakistan is also witnessing the presence of arsenic in the drinking water. As in other parts of Pakistan, here too the ground water is the main source of drinking water that can be extracted by motor pump or hand pump. In this area the presence of arsenic in the ground water can be related to three theories or facts:

1. Use of phosphatic fertilizer that may release arsenic due to phosphorus.
2. Oxidation of pyrite
3. Due to a reductive dissolution of metal oxy-hydroxide desorption of arsenic.

In this area phosphate fertilizers are extensively used on cotton and sugar cane crops which can be a reason for the elevated concentration of arsenic as found in many studies [17]. The emerging health problems of arsenic contaminated water are more prominent in Southern Punjab. The most affected areas are located near the Indus River like Rajan Pur, Rasul Pur in the district Rahim Yar Khan. In some rural villages the 'Curse of God' name is given to "Arsenicosis", indicating the physical pain and sufferings. Again, the main cause of the arsenic contamination of the ground water is the extensive use of fertilizers as Rahim Yar Khan is an important agriculture production land [18]. Initially only eight districts out of 34 in Punjab were screened for arsenic contamination by the PCRWR (Pakistan Council of Research in Water Resources) and the UNICEF (United Nations Children's Fund) and then in 2004-05 all the remaining districts were also covered. It was found that six districts namely Bahwalpur, Layyah. Multan, Muzzafar Garh, Okara and Sahiwal are at high risk. The water samples collected from these districts had the alarming arsenic level of 250-500µg/L (Fig. 1) while samples from 60% of the area of Punjab had an arsenic level of less than 10µg/L i.e. within safe limits.

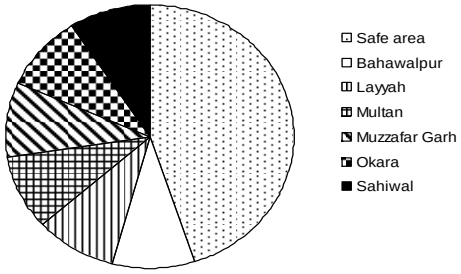

Fig.1. Districts at high risk of the arsenic level in Punjab Pakistan.

ARSENIC IN NEIGHBORING COUNTRIES

The arsenic contamination scenario has changed remarkably in Asian countries in the near past. Before the year 2000, only five major incidents of arsenic contamination of ground water were reported in Bangladesh, West Bengal, India and China among Asian countries. During 2000-2005 new sites were reported having ground water contaminated with arsenic in Mongolia, Cambodia, Myanmar, Nepal, Pakistan and Afghanistan [19].
Here the main focus is on Afghanistan, India and Bangladesh. According to the World Health Organization (WHO) in Bangladesh 42 districts have ground water contaminated with arsenic, greater than the permissible limits of 50 µg/L. Nail, hair and urine samples of the people living in the arsenic contaminated villages were analyzed and the people were found to suffer from arsenical skin lesions. The study revealed that adults can be afflicted by arsenical skin lesions if the water contained arsenic above 300µg/L; the average water intake for adults is 4L/day. Interestingly, if the nutrition status is poor then even low arsenic levels can cause arsenical skin lesions, while if the nutrition status is good even 400µg/L cannot generate the disease [20].

In Afghanistan, the Water and Sanitation group (WSG) of Afghanistan did the screening of the rural water supply schemes for arsenic in different villages with the help of UNICEF. Under this program they tested 647 wells out of which 565 were found to be arsenic free, 74 wells contained arsenic and 56 had arsenic ranging from 10-500µg/L. The predictable number of people at risk was about 500,000 [10].

In India, the Lower Ganga plain of West Bengal was initially found to be severely affected by

arsenic contamination, but later Bhojpur District, Bihar which is in the Middle Ganga plain was also found to be contaminated with arsenic. In a study conducted in these areas, water from 206 tube wells was analyzed for arsenic content and it showed that 56.8% had an arsenic concentration exceeding 50µg/L to 300µg/L. In the same study 390 adults and 160 children were medically examined and showed that 13% of the adults and 6.3% of the children had skin lesions, especially the children were more affected, which can be linked to malnutrition [21].

LESSONS LEARNT

There is a lot which can be learnt from the neighboring countries as they fight arsenic contamination. The public and private sector in Pakistan can both play a very effective role in this together so that they could educate and train the natives of affected areas in taking preventive measures against arsenic contamination.

An inspiring success story, in this regard, comes from West Bengal, India. There the Public Health Engineering (PHE) Department, with the collaboration of the UNICEF and local NGOs set up arsenic testing labs. The lab employees and trainee female members of the local population not only educate their communities about Arsenic contamination but also regularly collect samples from tube wells which are the common source of drinking and domestic-usage of water for the local people. If samples from a tube well give positive results for Arsenic, the PHE teams (trained local women) inform the local population about it and encourage them to collectively buy Activated Alumina Arsenic Filters for the affected tube well. In addition to employing local women as awareness and sampling resources, the PHE has also trained around 300 local women to work as tube well mechanics. These lady mechanics act on a self-help basis to repair tube wells and install and replace As Filters whenever needed. This makes it very cost effective for the local communities and affordable to maintain the arsenic free tube wells. This strategy has really helped the PHE in fighting Arsenic contamination on a war footing [22].

In Bangladesh, through the conducted survey of the rural communities the level of awareness was gauged and prevailed amongst the local community members as regards arsenic contamination through the water and soil. Throughout the survey it was ensured that native members of rural community were kept on board, educated and consulted to promote arsenic awareness. Gatherings amongst the village residents were organized to talk about the As hazards and public networks such as radio and TV were engaged to disseminate information regarding the adverse long term effects of Arsenic contamination. These activities drastically improved the household perceptions about the health impacts of arsenic contamination. Furthermore, different methods and technologies were identified for fighting arsenic contamination. Rural residents were not only educated about these methodologies but were also informed about the merits and demerits of each. This infused interest into the community members and encouraged their positive involvement [23].

The methods and technologies identified to fight back Arsenic were:

1. Three Kolshi (Pitcher) Method
2. Dugwell
3. Activated Alumina Method
4. Deep Tubewell

Similar strategies and models can be adopted in the affected rural areas of Pakistan and with the support of public-private partnerships.

Apart from Pakistan's neighboring countries, lessons can be learnt from other nations which have been successfully fighting this menace too. In Cambodia private philanthropists have taken it upon themselves to discover new ways of understanding and combating arsenic effectively. To improve the lives of the local rural community in this regard, these researchers test all the existing wells for arsenic contamination. If the test comes negative, they install another tube well in the vicinity and hand it over to the local community for domestic use. In case the test results show positive signs of Arsenic, the team finances the local community to buy a locally made rainwater-harvesting unit. Thus, not only helping them meet their domestic water needs but also providing them with a water resource free of arsenic [19].

ENDING NOTE

Keeping in view of the whole scenario, the following practices should be adopted:

1. Screening of the ground water / tube wells should be undertaken on a regular basis to keep an eye on the rise of arsenic contamination.
2. Provision of low cost testing facilities or apparatus.
3. Areas which are at a high risk like the Southern Punjab and also some sites in Sindh must be monitored and the arsenic removal systems should be made using locally available materials such as water filtering mediums.
4. Social awareness is a must. It can be done through print and electronic media. Besides that

volunteers should be employed to educate the masses in the affected villages about the harmful affects. More importantly the sources/ tube wells/ wells that have been screened and found contaminated should be marked or painted as 'Red' indicating the use of water as risky and those not contaminated by arsenic should be painted as 'Green' indicating 'safe' for drinking.

5. As the ground water is more contaminated, alternative water supply options should be introduced.

6. To determine the health risks associated with and caused by arsenic, the Government Health department should take steps so that the Epidemiological survey in various areas can be carried out as early as possible.

7. The health hazards caused by arsenic like 'Arsenicosis' and all the related study materials should be included in the curricula of the medical institutes.

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ВОДНИЯТ ПРОБЛЕМ НА ПАКИСТАН: АРСЕНЪТ КАТО ГЛАВНА ЗАПЛАХА

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(Резюме)

Арсенът (известен като ‘Sinkhia’ в Пакистан) се определя като най-опасната отрова. Обикновено той се среща във водите, главно от геологически източници или от замърсявания на околната среда. Като химичен елемент той е на 12-то място по разпространение в природата. Намира се в земната кора, атмосферата, скалите, живите организми и в природните води. Изследванията показват, че наличието му в атмосферата е с антропогенен произход. Арсенът образува неорганични и арсен-органични съединения. Най-важните неорганични вещества са арсенатите (As^{V+}) и арсенитите (As^{III+}). Неорганичните арсенови съединения могат да включват кислород, натрий, мед, калий, сяра и желязо, а органичните се образуват при взаимодействието му с въглерод и водород в органичните на растенията и животните. Известни са три основни пътища за приемане на арсена: чрез водата, храната (риба, морски храни, житни култури и водорасли) и въздуха (дишане, емисии от изгаряне на въглища). Освен тях най-сериозна заплаха за човешкото здраве представлява дългосрочното наличие на арсен в питейните води. В последните години това се смята за най-голямата заплаха в много части по света. Най-лошите въздействия се дължат на дозите и продължителността на въздействието. Те се проявяват дерматологични смущения при хронично или краткотрайно излагане на въздействието на арсен. Дерматологичните ефекти включват меланози (пигментация) и кератози (втвърдяване, загрубяване на места от кожата) като петна или дифузно разпространени. Хроничното излагане на въздействие може да причини неврологични, репродуктивни, сърдечно-съдови, хематологични, дихателни и диабетични ефекти върху хората. Както и в други места по света и в Пакистан хората са изложени на въздействието на арсена по различни начини: чрез приемане на храна, медицински препарати, вдишване и пр. В Пакистан няма достатъчно данни по отношение замърсяването с арсен на питейните води. Те са необходими за изработването на стратегия за решаване на здравните проблеми, причинени от водите, замърсени с арсен. Този обзор е опит за да се разгледат достъпните данни относно замърсяването с арсен в Пунджаб и Синдх и изобщо в Пакистан.