ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2014

Toxic Effects of Arsenic in Industrial Areas of Kanpur Nagar, (U.P.), India

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ABSTRACT*:* Arsenic concentration in drinking water supplies in industrial areas of Kanpur Nagar, Uttar Pradesh, India is high because of the presence of industrial wastes and runoff from agricultural land. The contamination of drinking water supplies with arsenic causes major health problem. Several studies have investigated long term exposure to environmental arsenic concentration using hair and nails. In the present study an attempt has been made to estimate the level of arsenic in drinking water, hair and nail of population living in industrial areas of Kanpur Nagar. Analysis was carried out by Atomic Absorption Spectrometry (AAS) for arsenic. This study reveals that in the arsenic affected areas of Kanpur, the concentration of arsenic in drinking water supplies should be monitored to evaluate the arsenic poisoning. We found the arithmetic mean of arsenic level is 2.4331, 0.5332 and 0.40604 in water, hair and nail respectively.

KEYWORDS*:* Arsenic, hair, nail, water, arsenicosis, carcinogen, health problem and toxicity.

I. INTRODUCTION

Arsenic is a semi-metal element in the periodic table. It is a chemical element with the symbol **"As"**. It is found naturally in rocks in the earth's crust. It is recognized as a poison and cancer causing substance, and within inorganic compounds. The word 'Arsenic' is taken from a Latin word ***arsenicum*** and Greek word ***arsenicos***. Arsenic compounds can be classified into three major forms: Inorganic, organic, and arsine gas. The most common inorganic trivalent arsenic compounds are arsenic trioxide, sodium arsenite, and arsenic trichloride. Pentavalent inorganic compounds are arsenic pentoxide, arsenic acid, and arsenates such as lead arsenate and calcium arsenate. Organic arsenic compounds may be trivalent (+3, arsenite) or pentavalent (+5, arsenate). Most organic arsenic compounds found in the environment are methylated as a result of biomethylation by organisms in soil or water. Organic arsenics, such as disodium methylarsenate (DSMA) and monosodium methylarsenate (MSMA), are used as herbicides. Organic arsenic compounds are registered for use as medicinal animal feed additives. Arsenobetaine or "fish arsenic", an organic form of arsenic, is found in seafood and is nontoxic. Arsine gas is formed by the reaction of hydrogen with arsenic and can have a garlic-like or fishy odour at high concentration.[3]The major source of arsenic exposure is drinking water that contains elevated levels of arsenic and others are food, air, pesticides, dust and folk remedies. Other potential sources of arsenic exposure are natural, industrial, medicinal, commercial products and occupational. It released in to the atmosphere by three ways- Natural activities, Human activities and Remobilization of historic sources.[2] Arsenic found in water in many forms-

Name	Abbreviation	Chemical formula
Arsenous acid (arsenite)	AsIII	As(OH)3
Arsenic acid (arsenate)	AsV	AsO(OH)3
Monomethylarsinic acid	MMAV	CH3AsO(OH)2
Monomethylarsinous acid	MMAIII	CH3As(OH)2

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Dimethylarsinic acid	DMAV	(CH3)2AsO(OH)
Dimethylarsinous acid	DMAIII	(CH3)2AsOH
Trimethylarsineoxide	TMAO	(CH3)3AsO

Their names as "acids" is a formality, these species are not aggressive acids but are merely the soluble forms of arsenic near neutral pH. Arsenic is normally found in higher concentrations in human hair and nails than in other parts of the body. This has been explained by the high content of keratin in these tissues.[9] Hairs and nails contain a broad concentration range of different elements. Among many human tissues, hair and nails are widely used as biomarkers of environmental burden of toxic due to easy sample collection, transportation, storage, and preparation for analysis.[8]Hair and nail samples are good indicators for certain toxic elements to which subjects have been exposed during the previous 2–18 months.[10] In people with no exposure to As the concentration of As in hair is generally 0.02-0.2 mg/kg.[4] Arsenic (As) is the 20 most abundant elements on earth. The greatest commercial use of inorganic arsenic is in wood preservatives with other major uses in pesticides (herbicides and termiticides). Small amounts of inorganic arsenic are used in production of glass and nonferrous alloys, and in the manufacture of electrical semiconductors. Organic arsenic is generally not used commercially. However, some organic arsenicals, such as derivatives of phenylarsenic acid are used as feed additives for pigs and poultry.

II. RELATED WORK

A lot of work had been done on arsenic previously by different researches in the present work an attempt has been made to review this work by analyzing arsenic level in water, hair and nail.
The survey is conducted in industrial areas of Kanpur nagar in which we divided it in to 5 divisions i.e. Vajidpur, Panki block C, J.K. colony, Dadanagar and Motinagar. At first the samples of water were taken for the preliminary examination of arsenic by arsenic field detection kit. Then we collect 30 samples of water from 5 areas of Kanpur nagar in bottels by left hand rule. Then we collect the samples of nail and hair from the same home in those 5 areas from where we had collected the water samples. We collected hair and nail samples mostly from women. The persons are taken different age group i.e. 0-15, 16-30, 31-45, 46-60 and 61-75. We collect all the nail samples in dram bottels and hair samples in polythine bags. Then all the samples of water, hair and nail were examined through atomic absorption spectrometry. The arithmetic mean of the result was calculated and compared with the toxic level. At last we told about the health effect which can be face by human in those areas.

III. TOXICITY AND HEALTH EFFECTS

Arsenic exerts its toxicity by inactivating up to 200 enzymes, especially those involved in cellular energy pathways and DNA synthesis and repair. Toxicological quick facts about arsenic: [3]

- Arsine gas is extremely toxic.
- Inorganic arsenics are more toxic than the organic forms.
- Trivalent arsenic compounds tend to be more toxic than pentavalent arsenic compounds.
- Metalloid arsenic is nontoxic because it is insoluble in water and body fluids.
- Arsenobetaine is the primary form of arsenic found in fish and is nontoxic.

In humans, soluble forms of ingested arsenic are well absorbed (60% to 90% absorption) from the gastrointestinal tract. The amount of arsenic absorbed by inhalation has not been determined precisely, but is also thought to be in the range of 60% to 90%.

HEALTH EFFECTS OF ACUTE EXPOSURE

- Both ingestion and inhalation may cause gastrointestinal effects such as nausea, diarrhoea and abdominal pain.
- Multi-organ failure may occur in severe cases following ingestion Inorganic arsenic is irritant to the eye and skin.

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- The immediate symptoms of acute arsenic poisoning include vomiting, abdominal pain and diarrhoea. These are followed by numbness and tingling of the extremities, muscle cramping and death, in extreme cases.[1]

HEALTH EFFECTS OF CHRONIC EXPOSURE

- Following chronic ingestion a range of non-specific symptoms of the respiratory tract, CNS, endocrine system, liver, kidneys or gastrointestinal system may occur.
- Chronic inhalation of arsenic may cause irritation of the mucous membranes leading to conjunctivitis, pharyngitis and rhinitis.[1]

HEALTH EFFECTS OF LONG-TERM EXPOSURE

- During long-term exposure to high levels of inorganic arsenic, the first changes are usually seen in the skin. Pigmentation changes and then skin lesions and hard patches on the palms of the hands and soles of the feet.
- Other effects of long-term exposure to high inorganic arsenic levels include peripheral neuropathy, gastrointestinal symptoms, conjunctivitis, diabetes, renal system effects, enlarged liver, bone marrow depression and destruction of erythrocytes, high blood pressure and cardiovascular disease.
- Inorganic arsenic is one of the few substances that have been shown to cause cancer in humans through consumption of drinking-water. Cancer usually takes more than 10 years to develop. Arsenic can cause cancers of the skin, bladder and lungs, and there is limited evidence that it may also cause cancers of the kidney, liver and prostate.[2]

The International Agency for Research on Cancer (IARC) has classified arsenic and arsenic compounds as *carcinogenic to humans*, which means that there is sufficient evidence for their carcinogenicity in humans.
Arsenic affects the body by many ways –Hematological Effects, Hepatic Effect, Renal Effects, Dermal Effects, Neurological Effects, Developmental Effects, Reproductive Effects, Genotoxicity Effects, Mutagenic Effects, Immunologic Effect, Carcinogenic Effect, Cancer of the Respiratory System, Cancer of the Skin, Biochemical Effects, Cardiovascular Effects, Hematopoietic Effects, Carcinogenic Effects, Cardiovascular Effects, Gastrointestinal Effect and Respiratory Effects. Furthermore, IARC has stated that arsenic in drinking-water is *carcinogenic to humans*. Arsenic has been classified as a known human carcinogen by multiple agencies based on the increased prevalence of lung and skin cancer observed in human populations exposed to arsenic. Ingestion of arsenic has been primarily associated with an increased risk of skin cancer and lung cancer. [6]

IV. MATERIALS AND METHODS

MATERIALS

This work has been done on 30 samples of water, 30 samples of hair and 30 samples of nail which are contaminated with arsenic. The materials which were used are bottles, dram, small polythine bags, electronic weighing machine, clip, blade, gloves, arsenic detection kit etc.

Chemical used-Ethanol, Thiourea, Methanol HCl, Chloroform, Arsenic trioxide, Urea, Distilled water, deionised water, Concentrated nitric acid (HNO_3) and 30% v/v hydrogen peroxide (H_2O_2).
Glassware Required- Beakers, Spatulas**,** Flat bottom flasks Pipettes, pipette tips**,** Funnels and Filter papers.

METHODS

SAMPLE COLLECTION

This study has been conducted on samples of water, hair and nail which were have arsenic. The samples were collected from the industrial areas of Kanpur city. The samples were chosen from Kanpur city because there were many

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

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industries in this city. Since the level of absorption is higher in hair and nail than other parts of body so I collected hair samples in the polythine bags. The nail samples were also collected in the small bottles.
After extraction of samples, they can be analyzed by many methods like- ICP-MS, FAAS, FIAS, XRD, ICP-AES, NAA, AFS, HPLC-ICP-MS, HPLC and AAS. After preparation of sample they analyzed by one of them. In this work the samples are analyzed by AAS (Atomic Absorption Spectrometry).

ATOMIC ABSORBTION SPECTROMETRY

Atomic absorption spectrometry (AA or AAS) is one of the commonest instrumental methods for analyzing for metals and some metalloids. Atomic-absorption (AA) spectrometry uses the absorption of light to measure the concentration of gas-phase atoms. Since samples are usually liquids or solids, the analyze atoms or ions must be vaporized in a flame or graphite furnace. The atoms absorb ultraviolet or visible light and make transitions to higher electronic energy levels. The analytic concentration is determined from the amount of absorption. Concentration measurements are usually determined from a working curve after calibrating the instrument with standards of known concentration.

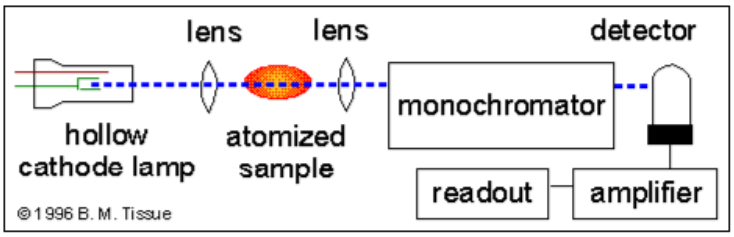


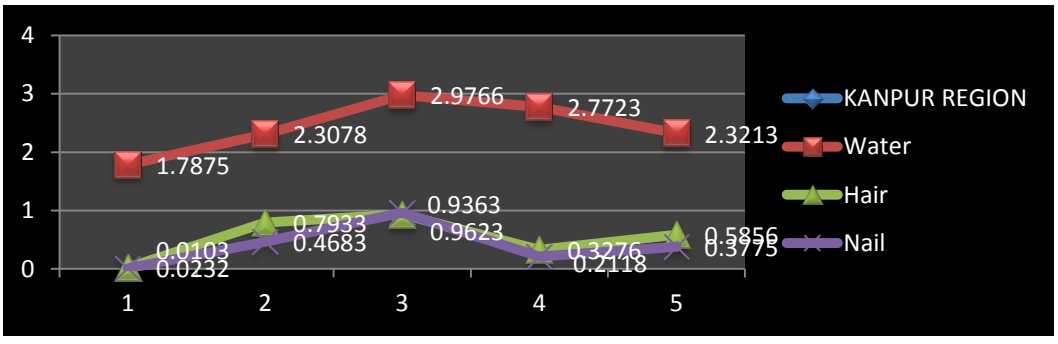
Figure 1 schematic diagram of Atomic Absorption Spectrometry

This is universally accepted technique, most of the researcher working on this technique. Absorption is so sensitive that it can measure down to parts per billion of a gram (µgdm–3) in a sample. The technique makes use of the wavelengths of light specifically absorbed by an element. They correspond to the energies needed to promote electrons from one energy level to another, higher, energy level. It requires standards with known analyte content to establish the relation between the measured absorbance and the analyte concentration and relies therefore on the Beer-Lambert Law.

V. EXPERIMENTAL RESULTS AND DISSCUTION

TABLE 1-Arithmetic mean table of industrial areas of Kanpur nagar (Arsenic contaminated water in different areas) –

Sample type	Vajidpur	Panki Block C	J. K. Colony	Dadanagar	Motinagar
Water	1.7875	2.3078	2.9766	2.7723	2.3213
Hair	0.0232	0.7933	0.9363	0.3276	0.5856
Nail	0.0103	0.4683	0.9623	0.2118	0.3775



In the table 1 we showed the relationship of the arithmetic mean of water, hair and nail in different areas (Vajidpur, Panki block-C, J.K. Colony, Dadanagar and Motinagar) of Kanpur nagar.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

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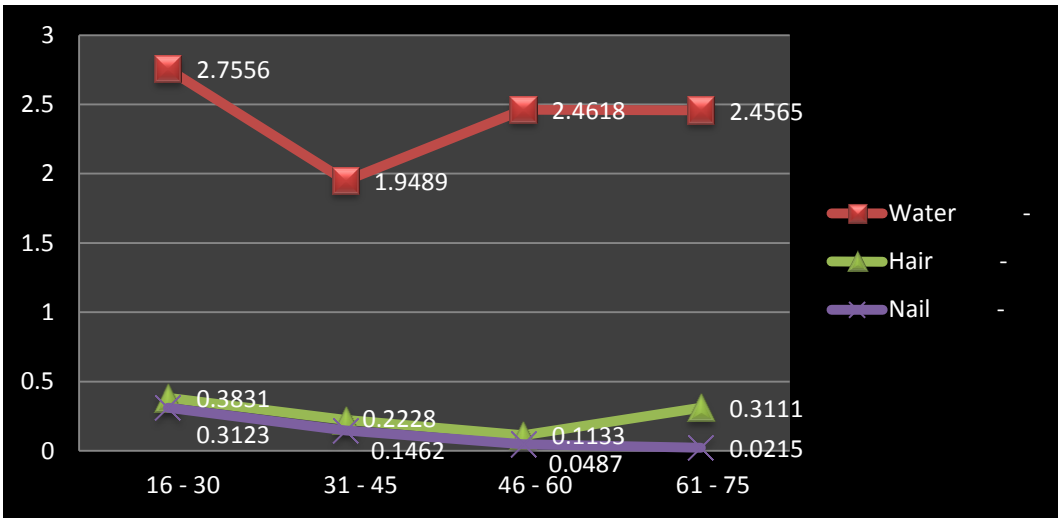
TABLE2-Arithmetic mean of industrial areas of Kanpur nagar (Arsenic water contamination in different age group) –

Age group	0 - 15	16 – 30	31 - 45	46 - 60	61 - 75
Water	-	2.7556	1.9489	2.4618	2.4565
Hair	-	0.3831	0.2228	0.1133	0.3111
Nail	-	0.3123	0.1462	0.0487	0.0215



In the table 2 we showed the arsenic arithmetic mean level of water, hair and nail in the different age groups (16 - 30, 31 - 45, 46 - 60 and 61 - 75).

The arsenic level in groundwater of sights of Kanpur nagar is very critical thread for the people living in that area. All the samples shows that arsenic level in groundwater much greater than the normal one [<0.05 mg/l, Indian Health Center (IHC)]. The nontoxic level of arsenic in water is 0.01 mg/l.

Yanez et al. studied in **2005** on the level of arsenic in two villages (Esquin and Illapata) of the Atacama Desert, Chile. He found the arsenic concentration in drinking water was 1.25 mg/ L, where As represented between 92 and 99.5% of the total arsenic of the consumed water.[7] However in the present study 40 % houses is found drinking water having arsenic level between 0.98 to 1.72 mg/l, which is similar to Yanez study. 33 % and 27 % found the level between 1.887- 2.987 mg/l and 2.984 – 3.987 mg/l respectively. **Goldsmith et al (1972)** in a study of 98 subjects drinking water with arsenic content is 1.4 mg/l. However in the present study 40 % houses is found drinking water having arsenic level between 0.98 to 1.72 mg/l, which is similar to Goldsmith study. **Saad et al. (2001),** showed that arsenic level of hair samples in which about 55% of the analyzed samples were within the range of allowable values (0.08- 0.25 mg/kg). However in the present study in 70 % people the arsenic level in hair is found 0.02 to 0.25 mg/kg which is similar to Saad study. **Mosaferi et al.** studied on the Correlation between Arsenic Concentration in Drinking Water and Human Hair, and he found the level of arsenic in hair was 0.26 mg arsenic/kg of hair as an average. However in present study the level found in hair is 0.02 to 0.25 mg/kg which is similar to Mosaferi study. **Liebscher and Smith (1968)** reported a range of 0.02 to 8.17 mg/kg in 1250 hair samples from persons living in the industrial city of Glasgow, Scotland. However the arsenic level in hair is found 0.02 to 0.25 mg/kg in present study which is similar to Smith and Liebscher study. **Rakib et al.** studied in **2013** in Bangladesh that the arsenic level in nail is 0.014 – 1.40 mg/kg which is not toxic. However in present study the level of arsenic in nail is found between 0.002 to 1.163 mg/kg which is similar to Rakib study.

ISSN: 2319-8753

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VI. CONCLUSION

On the basis of above observation it is concluded that if the consumption of the water which contain arsenic is not prohibited then the people of that areas may face such diseases or problems in future like skin lesions (hyper pigmentation, hyperkeratosis), peripheral neuropathy, gastrointestinal symptoms, diabetes, metallic taste, burning of the mouth, vomiting, diarrhoea, dehydration, general muscular cramps, renal system effects, cardiovascular diseases, tremors, stomach pain, nausea, depression, circulatory disorders, numbness in the hands and feet, unusual skin pigmentation (dappling of dark brown or white splotches), anaemia, vascular lesions, skin cancer and internal cancers (bladder, prostate, lung and other sites).
In humans, soluble forms of ingested arsenic are well absorbed (60% to 90% absorption) from the gastrointestinal tract. The amount of arsenic absorbed by inhalation has not been determined precisely, but is also thought to be in the range of 60% to 90%. Most tissues, except for skin, hair, and nails, rapidly clear arsenic. Arsenic undergoes methylation to less-toxic metabolites in the liver.

- To reduce the intake of arsenic from drinking-water in areas with naturally high levels in the groundwater.
- We can keep occupational exposure to arsenic and its components to low level. Public and health sector awareness is done for the harmful effects of high level of arsenic in groundwater and for escaping from its effects.
- We should discriminate between high-arsenic and low-arsenic water sources by painting hand pumps in different colours (e.g. red and green).
- When early signs of arsenic poisoning occur, we should keep the precautions for taking arsenic contaminated water and go to doctor for further treatment.
- We should monitor high-risk populations for early signs of arsenic poisoning, usually skin problems.

ACKNOWLEDGEMENT

I want to pay my sincere respect and honour to Dr. Anu Singla, (Reader/HOD) and my guide Mr. Pradeep Kumar, Lecturer, Institute of Forensic Science & Criminology, Bundelkhand University, Jhansi, for choosing me for this project work. I appreciate his energy and his explanation phenomena that helped me to understand the insight of the work and inspired me to give my best. A special thanks to my father, my family, honourable teachers and all my dear friends for their love and concrete support without which it was impossible to make this work done.

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ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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BIOGRAPHY

I am the student of PG in institute of forensic science and Criminology, Bundelkhand University, Jhansi, U.P., India and completed dissertation entitled "Toxic Effects of Arsenic in industrial areas of Kanpur nagar, Utter Pradesh, India under the supervision of Mr. Pradeep Kumar, Lecturer, Bundelkhand University, Jhansi.