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# Study on arsenic content of rice, it's hazards and domestic control to lower the value

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**Abstract**
Rice is a major agricultural and economic crop in India. In Indian sub continent more than quarter of land is used for cultivation of rice. It is very essential in southern and eastern part of India. In the north and central part wheat is frequently consumed still rice holds its own and is cooked daily as well as in festival and occasions. There is a rise in rice consumption among those who are vegetarians and vegans or are on a low-fat, gluten-free, or lactose-free diets.
It is a major global staple food crop that is grown under flooded conditions. Rice absorbs arsenic faster than many other plants and accumulates a high amount of arsenic of all the grain crops.
In India, the states of West Bengal, Jharkhand, Bihar, Uttar Pradesh, Assam, Manipur and Chhattisgarh are reported to be most affected by arsenic contamination of groundwater above the permissible level. Arsenic (As) poisoning from drinking water has been called the worst natural disaster in the history of mankind. An estimate of 137 million people is affected in 70 countries by arsenic poisoning. Arsenic is a potent carcinogen and is known to cause cancer of the skin, lung, kidney, bladder and liver.
So in the study types like organic and inorganic Arsenic are discussed. In Indian condition accumulation of Arsenic in Paddy is highlighted. The Arsenic poisoning, severity and after effects on mankind has been reviewed with reference study on lowering the value of Arsenic.

**Keywords:** Arsenic, gluten free, lactose free, Aesenic poisioning

## Introduction
Needless to mention, rice is the staple dish of several Indian states. It can be found in more than 40000 varieties all over the world. The most popular rice in India is divided in whole grain and white grain categories. White grain is a processed variety whereas the whole grain is unprocessed bran that is highly nutritional. People choose rice variety according to their personal preferences, flavors, culinary needs and health benefits.

## Objective of the Study
- Benefits of Rice
- To know about different types of Rice
- Arsenic types
- Rice and Arsenic relation
- Health hazards due to Arsenic
- Methods to lower the Arsenic value at home.

## Rice health benefits
- Aids Digestion
- Stabilizes blood sugar levels
- Slows the aging process
- Stimulates immunity
- Fights cancer
- Good for skin and hair
- Hikes metabolism
- Cures cardiovascular ailments

**Top most popular rice in India**

- White rice mainly cultivated in Tamilnadu.
- Brown rice one of the most healthy rice however the studies proven the presence of Arsenic.
- Red rice is iron rich rice. good for Diabetics.
- Parboiled rice Rich source of pottasium, iron, calcium, magnesium, also good for Diabetics.
- Palalkkadan Matta rice one of the famous rice verities in Kerala. Rich in Magnesium and calcium.
- Black rice, found in Tamilnadu, The vitamin enriched rice is full of antioxidants, is mostly used for pudding making.
- Sticky rice, the glutinous, waxy and sweet rice, having high Selenium content good for brain functioning and immunity. Popular in North east India, used for dessert making.
- Basmati rice, mainly cultivated in western subcontinent of India, This aromatic rice is full of calories, carbohydrates, vitamins and minerals.
- Wild rice historically grown in China and North America, one of expensive rice in India available online not in stores, having peculiar flavor but takes long time to cook.
- Jasmine rice, grown in Thailand south Asia, having Jasmine floral flavor and parallel health benefits.

**Cultivation**

It is a member of the grass family (like wheat and barley but it grows anywhere from 3 to 6 feet high) so it is a cereal grain. For its cultivation rice needs fairly specific climatic conditions. The seedlings are often planted underwater, or the fields flooded shortly afterwards. This is to protect the growing plant from weeds and vermin and is simply the cheapest form of weed and pest control; The plants do, however, require lots and lots of water in the early part of growth, followed by continuous hot dry weather. Rice absorbs arsenic faster than many other plants and accumulates a high amount of arsenic of all the grain crops from land and water.

Rice is unusual amongst terrestrial foods, particularly for staple crops, it is grown an aerobically. Under anaerobic conditions arsenic in soil is converted readily to arsenite which is mobile, leading to arsenic in rice grain being around 10-fold higher than for other crops. This occurs in soils which have no or limited anthropogenic contamination. Rice grain arsenic levels elevated further when grown in soils subject to anthropogenic contamination such as: arsenical pesticide use, base and precious mining and smelting impacted soils, and contaminated water irrigated soils.

All grains start life as whole grain. In its natural state growing in the fields, whole grain is the entire seed of the plant (also called the kernel), consisting of three parts: the bran, the germ and the endosperm. Brown rice is a whole grain and contains the entire grain kernel, all three of its parts. White rice, considered a refined grain, consisting only of the endosperm. The bran and germ, which are about 10-15% of the whole kernel, and contain many nutrients in rice, are removed in the milling process.

As reported by the FDA's 2013 study of rice products, brown rice had approximately twice the concentration of inorganic arsenic compared with white rice. Brown rice has significantly higher levels of Vitamin B, Manganese, phosphorous, iron and fiber than white rice. Over the five years analysis (2011-2015), it is found that the average level of Arsenic in brown rice is about 93 ppb.

Arsenic is naturally found in air, water, soil, heavily used as a pesticide, and is potentially dangerous to human health as well as to the ecosystem (Virender Sodhi, MD, Ayurveda). It is a carcinogen, and there is ample evidence that arsenic increases risk of bladder, prostate, skin, and lung cancers. The arsenic found in five servings of rice per week poses a hundred times more risk for cancer than acceptable.

In ancient times, it was used in a variety of potions of uncertain therapeutic value and was a favorite in various poison-for-hire schemes. In modern times, arsenic has been used in a variety of applications including as a pesticide, as a wood preservative and in the semiconductor industry.

A Report by ICAR recently prepared is set to cause alarm in Punjab and Haryana. The repot establishes that Punjab and Haryana feature among the 12 states in the country where groundwater contains arsenic beyond the permissible limit. The report further points to the fact that a large quantity of this contaminated water is used for agriculture, thus entering the food chain. The report further suggests that vegetables and other crops grown in the contaminated belt in the two states have high level of arsenic (The Tribune, November 26).

**Types of Arsenic**

Organic arsenic is in the form of a molecule that has at least one carbon atom, while inorganic arsenic generally refers to arsenic compounds with no carbon atoms.

Inorganic and organic arsenic occur naturally in the environment, with inorganic forms being most abundant. Inorganic arsenic is associated with other metals in igneous and sedimentary rocks, and it also occurs in combination with many other elements, especially oxygen, chlorine, and sulfur. Organic arsenic contains carbon and hydrogen.

Arsenic has been in food as long as humans have been consuming food. Because arsenic exists in soil and water, incorporation into most plants and food, including rice, is inevitable. Arsenic is present in a wide array of foods, including flour, corn, wheat, fruit, poultry, rice and vegetables, as well as beer and wine, fruit juices and water.

Chronic exposure to inorganic arsenic can elevate the risk of cancer of various organs, as well as skin cancer. In epidemiological studies observing the effects of poor water quality, particularly in developing countries, scientists have found that high oral exposure to arsenic over time causes adverse health effects.

The inorganic arsenic is more hazardous and causes long-term health effects. Rice contains inorganic arsenic. According to the 2016 FDA risk assessment report on arsenic in rice, here are the average concentrations of inorganic arsenic in rice and rice products:

- 92 parts per billion (ppb) in white rice
- 154 ppb in brown rice
- 104 ppb in infants' dry white-rice cereal
- 119 ppb in infants' dry brown-rice cereal (FDA, 2016).

(1 ppb = one part per billion, or one microgram or one millionth of a gram of substance per liter of water. This is equivalent to one drop of water in a swimming pool, adding a pinch of salt to a 10-ton bag of potato chips, or three seconds in a century)

Due to high amounts of arsenic content, children should not feed too many rice products, as it can negatively affect their immune system.

A study surveyed arsenic in various rice varieties from different parts of the world to determine the effect of arsenic exposure on rice. The American long grain rice had the greatest arsenic levels. The rice from India, Pakistan and Bangladesh had less arsenic than American rice. The experiment demonstrated that the rice plant nutrient status is impacted by arsenic exposure

- FDA, ALARA stands for As Low As Reasonably Achievable and relates to the process of setting Maximum Levels (MLs).for example, that toxicologists determine that 50 ppb of chemical X is safe – it would not be expected to produce harm. But the food industry (growers and processors) is able to keep chemical X below 10 ppb without disrupting the food supply. This is where the ALARA principle say the limit should be set at 10 ppb, as low as can reasonably and reliably got it.
- The FDA established a guidance level of 100 ppb of inorganic arsenic in infant rice cereal. It did not set a level for rice destined for use in the general population. The FDA did recommend that pregnant women eat a variety of grains, and that infants be given a variety of fortified infant cereals. It also recommended that individuals eat a balanced diet, including a variety of grains.
- The European Food Safety Authority (EFSA) established limits for rice products distributed in the European Union, which went into effect in January 2016. These limits are 300 ppb for rice cakes and rice crackers, 250 ppb for brown rice and parboiled rice, 200 ppb for white rice, and 100 ppb for rice destined for the production of food for infants and small children.
- In July of 2014, the Codex Alimentarius Commission (Codex) adopted a standard ML of 200 ppb for white rice (polished rice).

In a study the arsenic in rice samples from the USA averaged overall about double than the arsenic levels in rice from Asia. The scientists concluded that the highest arsenic levels in rice from the USA was due to the heavy use of arsenic-based pesticides. Makes it clear why there are still arsenic residues in the environment even if one don't add any new pesticides. However, humans are not arsenic resistant. Therefore, rice grown organically often takes up arsenic too, although organic rice is still a better choice, because it will have less of other toxic chemicals.

In a surprising twist, brown rice has 80 percent more arsenic than white rice of the same type since arsenic accumulates in the grain's outer layers. Brown rice from California, India, or Pakistan is the best choices in this category,

The Consumer Reports study, US also analyzed arsenic levels in other grains. The data shows that quinoa, amaranth, buckwheat, millet, and polenta all contain lower Inorganic Arsenic levels, making them good alternatives. Bulgur, barley, and faro also contain negligible amounts of arsenic.

**Health effects**

Inorganic arsenic is a confirmed carcinogen and is the most significant chemical contaminant in drinking-water globally. Inorganic arsenic compounds (such as those found in water) are highly toxic while organic arsenic compounds (such as those found in seafood) are less harmful to health.

**Acute effects**

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.

**Long-term effects**

The first symptoms of long-term exposure to high levels of inorganic arsenic (for example, through drinking-water and food) are usually observed in the skin, and include pigmentation changes, skin lesions and hard patches on the palms and soles of the feet (hyperkeratosis). These occur after a minimum exposure of approximately five years and may be a precursor to skin cancer.

In addition to skin cancer, long-term exposure to arsenic may also cause cancers of the bladder and lungs. Other adverse health effects that may be associated with long-term ingestion of inorganic arsenic include developmental effects, diabetes, pulmonary disease, and cardiovascular disease. Arsenic-induced myocardial infarction, in particular, can be a significant cause of excess mortality. In China (Province of Taiwan), arsenic exposure has been linked to "Blackfoot disease", which is a severe disease of blood vessels leading to gangrene. This disease has not been observed in other parts of the world however, and it is possible that malnutrition contributes to its development.

Arsenic is also associated with adverse pregnancy outcomes and infant mortality, with impacts on child health, and exposure in utero and in early childhood has been linked to increases in mortality in young adults due to multiple cancers, lung disease, heart attacks, and kidney failure. Numerous studies have demonstrated negative impacts of arsenic exposure on cognitive development, intelligence, and memory.

**Magnitude of the problem**

Arsenic in Bangladesh has attracted much attention since recognition in the 1990s of its wide occurrence in well-water in that country. Since this time, significant progress has since been made and the number of people exposed to arsenic exceeding the Bangladesh drinking-water quality standard has decreased by approximately 40%. Despite these efforts, it was estimated that in 2012 in Bangladesh, about 19 million people were still exposed to arsenic concentrations above the national standard of 50 μg/L and 39 million people above the WHO provisional guideline value of 10 μg/L. In a highly affected area of Bangladesh, 21.4% of all deaths in the area were attributed to arsenic levels above 10 μg/L in drinking-water.

**To Buy**

**Review of Literature**

**Contamination of Paddy Soil and Rice with Arsenic: (**Khageshwar Singh Patel, Bharat Lal Sahu, Shobhana Ramteke, Elza Bontempi, School of Studies in Chemistry/Environmental Science, Pt. Ravishankar Shukla University, Raipur, India INSTM and Chemistry for Technologies Laboratory, University of Brescia, Brescia, Italy, Journal of Environmental Protection, 2016, 7, 689-698)

According to the study the drinking water and food are main pathway entry of the Arsenic in humans and animals. Their in-takes cause diseases *i.e.* skin cancer, vascular disorder, etc. A wide variety of the rice is cultivated in the central India. The field soil and rice cultivated in the summer season at Koudikasa village, central India were selected for the Arsenic contamination studies. The concentration (n = 20) of total-As (AsT) in the field soil, rice grain, husk, straw and root was ranged from 44 - 270, 0.17 - 0.72, 0.40 - 1.58, 2.5 - 5.9 and 204 - 354 mg/kg with mean value of 126 ± 28, 0.47 ± 0.07, 0.83 ± 0.15, 4.2±0.5 and 276 ± 21 mg/kg, respectively. The total arsenic, monomethyl arsenonate, dimethylarsi-nite and inorganic As in the rice grain are quantified**.** The studied area falls in a tribal belt with population of ≈0.1 million over 155 villages. Among them, Koudikasa village (area ≈ 5 $km^2$) was selected for the proposed studies due to Arsenic contamination of the environment at the hazardous levels.

Twenty water samples (once in a month) in duplicate from August-November, 2012 were taken from 20 different rice fields. Twenty composite soil samples (0 - 10 -cm depth) were collected after harvesting of rice paddy (December, 2009) from 20 fields. Rice grains were separated from the plants by hand picking in December, 2012 from the field similarly, the straw and root of the rice plant were collected.

The field water and soil were found to be contaminated with As at dangerous levels, may be due to geogenic origins. The high yield rice variety *i.e.* IR-64, Kalinga, Ek Hazar Das, M2, Zero JR, etc. was found to be more sensitive to the As accumulation. The feeding of straw to the domestic animals seems to be a potential pathway entry of As. The rice root was marked as hyper phytoextractants for accumulating As from the surface soil.

**Characterization of Arsenic contaminated Rice (*Oryza sativa* L.) through RAPD Markers**

(Biswarup Mukherjee, Pritam Das, Tathagata Roy Chaudhuri and Tapash Dasgupta Department of Genetics and Plant Breeding, Institute of Agricultural Science, University of Calcutta, Department of Botany, Asutosh College, Kolkata, IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 5, Issue 1(Sep.- Oct. 2013), PP 10-14)

Study tells about Rice, being cultivated under anaerobic condition is vulnerable to arsenite, a mobile arsenic speciation. Both arsenate and arsenite are highly toxic to human body.

**Plant materials:** The study was conducted in Nonaghata (Nadia) and De-ganga (North 24 parganas) with 40 genotypes of rice procured from different research station of India (CRRI, Cuttack, Assam) and abroad (IRRI Philippines and Cornell University, USA) in Boro season. These include some genotypes which have been identified as susceptible and some of them are tolerant for arsenic uptake.

**DNA extraction from plant samples:** Two young leaves (100 mg) were taken from each of the plant. They were carefully washed under sterile distilled water to get rid of all potential sources of contamination and DNA extraction was done by using QIAGEN plant DNA extraction kit.

**PCR reaction for amplification by RAPD markers:** A total of 10 different decamer random primers were selected for the amplification of all DNA samples used in the sample. Amplifications were performed in 0.2 ml PCR tubes in a thermal cycler: 94 °C for 5 min of initial denaturation followed by 36 cycles each of denaturation at 94 °C for 30 sec, annealing at 36 °C for 30 sec and polymerization at 72 °C for 1.5 min. After the last cycle the samples were incubated for an additional 5 min at 72 °C until they were analyzed. All reactions were performed thrice and only reproducible bands were taken into consideration for analysis.

A few varieties have been identified with low arsenic. Simultaneously some of them were characterized at molecular level by RAPD technique.

**Assessing the effect of arsenic contamination on modern rice production: Evidences from a Farm Level Study (M.Shahe Alam, A. Islam, Bangladesh J. Agric. Econs. XXXIV, 1&2 (2011) 15-28)**

The southeastern and southwestern parts of Bangladesh are naturally contaminated with arsenic exposing. A study was undertaken in three arsenic contaminated upazilas namely Kachua, Bhanga and Faridpur, aiming at understanding the possible negative effects of arsenic contamination on crop production. Sample survey was carried out to generate primary data.

Two-stage sampling procedure was followed in order to select the sample farms. At the first stage, two adjacent villages under each of the selected upazilas were identified purposively and then a comprehensive list of the rice producing farms in each village was prepared by taking help of Sub-Assistant Agriculture Officer (SAAO) of the respective areas. At the second stage, the farms those used STWs for crop production were identified and out of them 50 farms under each village were selected following random sampling technique. Data were collected through directly interviewing the selected farmers using pre-designed questionnaire during November 2009 to June 2010. Collected data were scrutinized, edited and compiled using appropriate computer software. Productivity variability and the factors influencing level of productivity were identified. Analysis reveals that the share of agriculture income was higher for the farms under Bhanga (48%) compared to that under Kachua (46%). More than 70% of the sample households faced various arsenic related problems in rice production. Arsenic contamination resulted in less tillering, shorter plants, uneven plant growth and finally, decreased yield. Rice farmers adopted few practices for overcoming the problem, such as draining out of water from the rice fields, applying adequate fertilizers to the rice fields. Land degradation due to continued use of arsenic contaminated irrigation was reported. Due to the application of extra fertilizer and labour, the cost of modern Boro rice production in the more arsenic contaminated plots was 5% higher compared to that in less contaminated plots. Yields of MV (Modern variety) boro rice in more contaminated plots were significantly low resulting in lower gross return and profitability. Power tiller cost (a proxy for use of tiller), distance of plot from the STW, labour use, frequency of irrigation etc were the dominant determinants of MV Boro rice production in the sample arsenic prone areas.

**Level Arsenic in rice: The effects of cooking (A. Raab, J. Feldmann & A.A. Meharg)**

Sponsor’s project number: C01049, Rethinking Rice Preparation for Highly Efficient Removal of Inorganic Arsenic Using Percolating Cooking Water.

In conventional rice cooking water and grain are in continuous contact, and it is known that the larger the water rice cooking ratio, the more Arsenic removed by cooking, suggesting that the Arsenic in the grain is mobile in water. Experiments were designed where rice is cooked in a continual stream of percolating near boiling water, either low in $As_i$, or $As_i$ free. This has the advantage of not only exposing grain to large volumes of cooking water, but also physically removes any $As_i$ leached from the grain into the water receiving vessel. The relationship between cooking water volume and $As_i$ removal in conventional rice cooking was demonstrated for the rice types under study. At a water-to-rice cooking ratio of 12:1, 57±5% of Arsenic could be removed.

Two types of percolating technology were tested, one where the cooking water was recycled through condensing boiling water steam and passing the freshly distilled hot water through the grain in a laboratory setting, and one where tap water was used to cook the rice held in an off-the-shelf coffee percolator in a domestic setting. Both approaches proved highly effective in removing $As_i$ from the cooking rice, with up to 85% of $As_i$ removed from individual rice types. For the recycled water experiment 59±8% and 69±10% of $As_i$ was removed, on average, compared to uncooked rice for polished (n=27) and wholegrain (n=13) rice, respectively. For coffee percolation there was no difference between wholegrain and polished rice, and the effectiveness of $As_i$ removal was 49±7% across 6 wholegrain and 6 polished rice samples. The manuscript explores the potential applications and further optimization of this percolating cooking water, high $As_i$ removal, discovery.

The experiment that related $As_i$ content of cooked rice to rice cooking volume found a linear relationship, where the greater the volume of cooking water the greater the removal of $As_i$ from the cooked rice. GLM analysis found that whether the rice was wholegrain or polished ($P<0.001$), the volume of water used to cook the rice ($P<0.001$) and the interaction between rice type (wholegrain or polished) and cooking volume ($P<0.001$) were all highly significant with respect to the $As_i$ content of the cooked rice. Uncooked wholegrain rice had higher $As_i$ content in uncooked rice than polished, ~2-fold higher on average, but $As_i$ was more efficiently removed from wholegrain and by the highly significant rice type cooking volume interaction term. Up to 70% $As_i$ could be removed at the highest water to rice ratio (12:1), with average removal of 57±5% across all rice types at the 12:1 ratio as compared to uncooked rice, and 53±5% and 61±3% for polished and wholegrain, respectively, with whole grain having higher initial inorganic arsenic concentrations, so more to remove. This figure for all rice was 29±5% and 29±4% at ratios of 3:1 and 6:1 respectively

## Conclusion

To reduce arsenic content of cooked rice, specifically the inorganic component, rinse washing and high volume of cooking water are effective. Then the excess water can be drained, once it is cooked, which gets rid of up to 60% of arsenic levels in rice. Processed rice products should be avoided such as rice cakes, Rice Krispies, and more. Rice from India, Pakistan, Bangladesh which are low in arsenic and Lundberg Farms brand, which are regularly tested for arsenic should be consumed. Diet can also be diversified. Other grains which are low in arsenic than rice: amaranth, millet, buckwheat, bulgur, barley, and quinoa can be included in diet. Rice should be eaten in moderation to avoid the toxic effects of arsenic found in rice.

Traditional South east Asian methods of rice cooking involved extensive rinsing of the uncooked grain followed by cooking the rice in a large excess of water and discarding that water on cessation of cooking and this was found to reduce As content of food by up to 45% and 57% when As free water was used. Steaming is another traditional cooking approach, where rice is not directly exposed to cooking water, but steaming can only remove up ~10% of As.

## Prevention and control

The most important action in affected communities is the prevention of further exposure to arsenic by the provision of a safe water supply for drinking, food preparation and irrigation of food crops. There are a number of options to reduce levels of arsenic in water.

- High-arsenic sources, such as groundwater should be substituted, with low-arsenic, microbiologically safe sources such as rain water and treated surface water.
- Arsenic removal systems should be installed – either centralized or domestic and the appropriate disposal of the removed arsenic should be ensured. Technologies for arsenic removal include oxidation, coagulation-precipitation, absorption, ion exchange, and membrane techniques.

The symptoms and signs caused by long-term elevated exposure to inorganic arsenic differ between individuals, population groups and geographical areas. Thus, there is no universal definition of the disease caused by arsenic. This complicates the assessment of the burden on health of arsenic. Similarly; there is no method to distinguish cases of cancer caused by arsenic from cancers induced by other factors. As a result, there is no reliable estimate of the magnitude of the problem worldwide.

## Future Research Implications

- More research is needed in arsenic research in crop plants in different agro climatic situation to have a meaningful and stable conclusion so that the farmers and also the people do not suffer from arsenic hazards at least from the consumption of rice.
- There are an increasing number of effective and low-cost options for removing arsenic from small or household supplies, though there is still limited evidence about the extent to which such systems are used effectively over sustained periods of time.
- Education and community engagement are key factors for ensuring successful interventions.
- There is a need for community members to understand the risks of high arsenic exposure and the sources of arsenic exposure, including the intake of arsenic by crops (e.g. rice) from irrigation water.
- High-risk populations should also be monitored for early signs of arsenic poisoning.

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