

Household Water Treatment for Arsenic Removal Fact Sheet: Oxidation

Passive Oxidation

Potential Treatment Capacity

Very Effective For:	Somewhat Effective For:	Not Effective For:
	<ul style="list-style-type: none"> • Arsenic • Turbidity • Pathogens • Taste, odour, colour 	<ul style="list-style-type: none"> • Chemicals

What Is Passive Oxidation?

Passive oxidation uses iron compounds that naturally reduce the arsenic content of groundwater. When groundwater that naturally contains dissolved $\text{Fe}(\text{OH})_2$ is left to stand in containers, the iron undergoes a natural chemical process called oxidation (when an element loses electrons). It changes form into $\text{Fe}(\text{OH})_3$ and precipitates out (or becomes solid). Arsenic adsorbs or sticks to the iron precipitate. The combined iron and arsenic particles then settle to the bottom of the container, thereby removing the arsenic from the water. This technology does not require chemicals; it relies only on natural oxidation, adsorption and sedimentation that take place when both iron and arsenic are present in the water. Generally, the higher the level of iron in the groundwater, the better the arsenic removal.

Passive oxidation is seen as an easy technology for users in some areas to adopt because of the natural habits of some rural people to store their water in containers before they drink it. However, its performance at removing arsenic to safe levels has not been proven.

How Does It Remove Arsenic?

Naturally occurring iron precipitates of $\text{Fe}(\text{OH})_3$, produced from the oxidation of dissolved iron $\text{Fe}(\text{OH})_2$ present in groundwater, is a good adsorbent for arsenic. The method is based on co-precipitation with iron and sedimentation. It does not require the use of chemicals, but requires aeration (oxygen), settling and iron rich water.

The amount of arsenic removal depends on the concentration of iron in water.

Operation

- Stir the water for 2 minutes
- Leave water overnight in an open container



Passive Oxidation in locally available water jars
(Credit: T. Ngai)

Key Information

Treatment Efficiency	Output	Cost
Typically 30 - 50% arsenic removal	No limit	Minimal cost

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Solar Oxidation

Potential Treatment Capacity

Very Effective For:	Somewhat Effective For:	Not Effective For:
<ul style="list-style-type: none"> • Arsenic • Pathogens 		<ul style="list-style-type: none"> • Turbidity • Chemicals • Taste, odour, colour

What Is SORAS?

The SORAS (Solar Oxidation and Removal of Arsenic) method is similar to the SODIS method of water treatment, but also requires the addition of lemon juice. Ultraviolet (UV) rays from the sun cause the oxidation (loss of electrons) of As(III), changing it into As(V). The As(V) is strongly attracted to iron hydroxide particles naturally present in the water, and adsorbs (sticks) to these particles. The As(V)/Fe(OH)₃ co-precipitate (become solid particles) which settle to the bottom of the container.

How Does It Remove Arsenic?

SORAS removes arsenic using a two-step procedure:

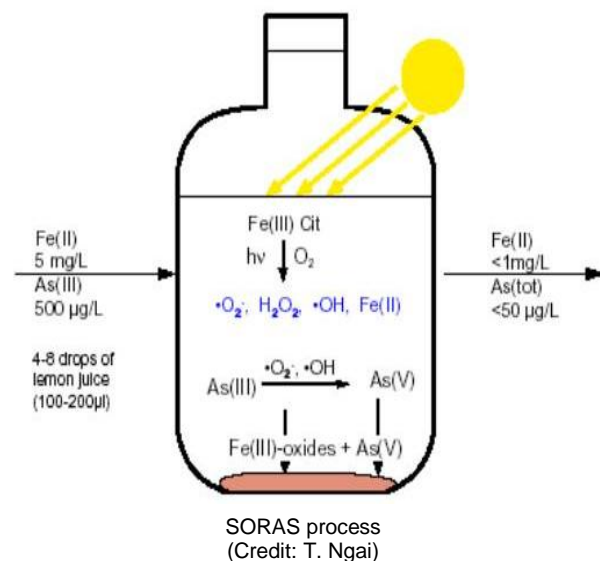
- First step: As(III), which only weakly adsorbs to iron hydroxide, is oxidized by the sun to the As(V), which strongly adsorbs to iron hydroxide
- Second step: the iron hydroxide precipitates with the adsorbed arsenic settle to the bottom of the container

Instead of adding chemical oxidants such as chlorine or permanganate, reactive oxidants are produced photo chemically using sunlight.

Operation

- Fill PET (or other UV-A) transparent bottles with water
- Add lemon juice to bottles
- Place the bottled in the sunlight for 1-2 days
- During the night, place the bottles in vertical position so particles can settle
- Decant clear water into a clean container, it may be filtered through a cloth or a ceramic filter

Photo-oxidation and removal of As



Key Information

Treatment Efficiency	Output	Cost
If iron > 8 ppm, 75-90% arsenic removal If iron < 5 ppm, <50 % arsenic removal Excellent microbial removal (99+%)	No limit	Minimal

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Asia Arsenic Network Filter

Potential Treatment Capacity

Very Effective For:	Somewhat Effective For:	Not Effective For:
<ul style="list-style-type: none"> • Arsenic • Most pathogens • Turbidity • Taste, odour, colour 		<ul style="list-style-type: none"> • Viruses • Chemicals

What Is Asia Arsenic Network Filter?

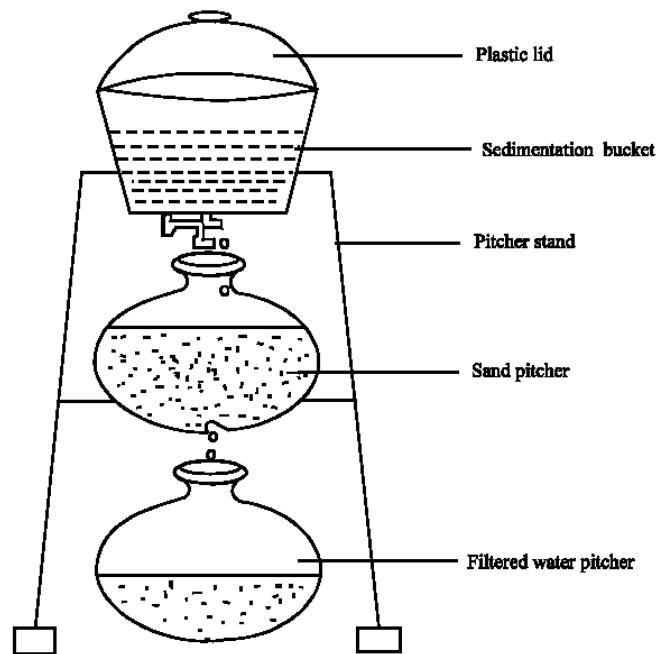
The Asia Arsenic Network Filter consists of an upper plastic bucket with a lid and tap, and two clay pitchers (or plastic buckets) that are positioned so water flows from one container to the next. The process consists of manual aeration, oxidation of iron naturally present in the water, and the co-precipitation of the arsenic and the iron. Arsenic removal depends on iron concentrations in water. The process is completed by filtering the water through sand in the second bucket. Treated water is collected from the bottom bucket.

How Does It Remove Arsenic?

Water added to the upper bucket is stirred and then allowed to stand. The dissolved iron compound $\text{Fe}(\text{OH})_2$ naturally present in the groundwater undergoes a natural chemical process called oxidation (when an element loses electrons). It becomes $\text{Fe}(\text{OH})_3$, which precipitates out or becomes solid. Arsenic strongly adsorbs (sticks to) $\text{Fe}(\text{OH})_3$. The combined iron and arsenic particles settle to the bottom of the container, thereby removing the arsenic from the water. The water is then filtered through sand, which retains any particles of iron and arsenic.

Operation

- Pour raw water into the top bucket and manually stir for 2 minutes
- Let water settle for 6 hours
- Open the tap in the top bucket and let the water flow through the middle bucket, which contains 2 kg of coarse sand
- Collect treated water from the bottom bucket



Asia Arsenic Network Filter
(Credit: Asia Arsenic Network, 2001)

Key Information

Treatment Efficiency	Production	Cost
Typically 70-80% arsenic removal	20 litres/6 hours	\$15-20 capital cost

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References

Roberts, L.C., S.J. Hug, T. Ruettimann, MD.M. Billah, A.W. Khan, and M.T. Rahman, (2003). Arsenic removal with iron(II) and iron(III) in waters with high silicate and phosphate concentrations (2003). Environmental Science & Technology, Web Published November 18, 2003, VOL 38 NO.1, 2004
Available at: <http://pubs.acs.org/doi/abs/10.1021/es0343205>

Sutherland, D., M. Woolgar, Dr. Nuruzzaman, T. Claydon. (2001). Rapid assessment of household level arsenic removal technologies: Phase II Executive Summary. WS Atkins International Ltd., Bangladesh Arsenic Mitigation Water Supply Project and Water Aid Bangladesh. Bangladesh and United Kingdom.

Available at: www.wateraid.org/documents/phs2execsum.pdf

Full Phase I Report available at: www.wateraid.org/documents/phs1report.pdf

Full Phase II Report available at: www.wateraid.org/documents/phs2fullrpt.pdf

World Bank Water and Sanitation Program (2005). Towards a more effective operational response: Arsenic contamination of groundwater in South and East Asia countries, Volumes I & II. Available at:

<http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/0,,contentMDK:22392781~pagePK:146736~piPK:146830~theSitePK:223547,00.html>

Further Information

Solar Oxidation and Removal of Arsenic (SORAS):

SORAS Paper. By: Martin Wegelin, Daniel Gechter, Stephan Hug, Abdullah Mahmud, Abdul Motaleb. No Date. Available at:

http://phs4.harvard.edu/~wilson/arsenic/remediation/sodis/SORAS_Paper.html

Presentation: Arsenic Removal by Solar Oxidation in Groundwater of Los Pereyra Tucumán Province, Argentina. By: J. d'Hiriart, M.V. Hidalgo, National University of Tucumán, M.G. García, National University of Córdoba, and M.I. Litter, M.A. Blesa National Atomic Commission Argentina. No Date. Available at: www.cnea.gov.ar/xxi/ambiental/iberoarsen/docs/presentationAs2006litter.pdf

Presentation: Innovative and Sustainable Technologies to Address the Global Arsenic Crisis. By: Susan Murcott and Tommy Ngai, Civil and Environmental Engineering Department, Massachusetts Institute of Technology. (2005.) Available at:

www.sandia.gov/water/Arsenic2005/2005tech_session/Murcott_pres.pdf

Asia Arsenic Network Filter:

Delawar, H.K.M. et al. (2006). A Comparative Study of Household Groundwater Arsenic Removal Technologies and Their Water Quality Parameters. Journal of Applied Sciences 6(10):2193-2200. Available at:

[www.scialert.net/pdfs/jas/2006/2193-](http://www.scialert.net/pdfs/jas/2006/2193-2200.pdf?sess=jJghHkjfd76K8JKHgh76JG7FHGDredhgJgh7GkjH7Gkkg57KJhT&userid=jhfgJKH78Jgh7GkjH7Gkkg57KJhT68JKHgh76JG7Ff)

[2200.pdf?sess=jJghHkjfd76K8JKHgh76JG7FHGDredhgJgh7GkjH7Gkkg57KJhT&userid=jhfgJKH78Jgh7GkjH7Gkkg57KJhT68JKHgh76JG7Ff](http://www.scialert.net/pdfs/jas/2006/2193-2200.pdf?sess=jJghHkjfd76K8JKHgh76JG7FHGDredhgJgh7GkjH7Gkkg57KJhT&userid=jhfgJKH78Jgh7GkjH7Gkkg57KJhT68JKHgh76JG7Ff)

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