ECAR - FAQ

Answers to Frequently Asked Questions (FAQs) about ElectroChemical Arsenic Remediation (ECAR)

http://arsenic.lbl.gov

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1. How does ECAR work?

ECAR stands for ElectroChemical Arsenic Remediation. In ECAR, electricity is used to quickly dissolve iron in water. This forms a type of rust that readily binds to arsenic in the water. The rust aggregates, forming larger particles that can be separated from the water through filtration or settling. The water is left arsenic-safe. For more information, see http://gadgillab.berkeley.edu/research/water/arsenic_removal/.

2. What is the arsenic content of ECAR-treated water? Are any contaminants added in the ECAR process?

ECAR treatment is capable of reducing arsenic to below 2 ppb. The World Health Organization recommends a maximum arsenic concentration of 10 ppb in drinking water. Our design goal is to consistently produce less than 5 ppb. No additional contaminants appear in the treated water.

ECAR treatment alone does not remove biological contamination. Biological contamination can be easily removed by adding either Chlorination or UV disinfection. We note here that the provision of drinking water to the community has to be accompanied by: (1) appropriate community education in health and hygiene practices, and (2) the introduction (if necessary) and use of narrow-mouthed vessels by the households for collection, transport, and storage of water to reduce the possibility of recontamination.

3. How long does ECAR take to remove arsenic?

ECAR is currently a batch process in two stages – electrolysis and separation. The electrolysis time is about 1.5 hours for typical groundwaters in West Bengal and Bangladesh. The separation stage is typically an additional 2 hours, using alum. We envision a treatment center with at least 1 day of water storage capacity, allowing a reliable daily supply of potable water to the community, at an affordable price.

4. How much power and electrical energy is required? How does power quality affect ECAR performance?

Our current 100L prototype uses about 0.36 kWh to remove arsenic from one cubic meter (1000 L) of ground water with 400 ppb arsenic. The maximum power demand from the prototype is less than 200 Watts.

ECAR treatment is relatively insensitive to power quality. The batch process allows for electricity interruptions, and the equipment can be made robust against voltage surges, sags, and spikes.

5. Where will the electricity come from?

Our preferred source of electricity is the grid (even if the grid power has several interruptions each day). The voltage requirement for ECAR treatment is about 3V. It is easy to provide this voltage using grid electricity, solar panels, or even 12V car batteries. We envision ECAR being used in a community center, where the cost of the electricity source is shared over many users.

6. How much drinking water is provided per person per day?

Our design goal is 10 liters (2.5 gallons) per person per day. Scientific literature estimates that a person needs at most 4 liters (1 gallon) per day for direct consumption. Including use for washing pots and pans, and use in cooking etc., the Indian Health Ministry estimates 7 liters per person per day as adequate.

7. How much does ECAR treatment cost per person per day (or per year)?

We estimate the operating costs to ECAR to be 22 cents/m^3 (0.022 cents/L) or 12.3 Indian rupees/m^3 (assumes exchange of 56 rupees/dollar). This estimate excludes capital, maintenance, and overhead costs. We estimate that the cost of civil works, equipment capital, maintenance, salaries for operators, management, overheads, and quality control costs, will make the final price of arsenic-free water to about **Indian rupees 2 for 10 liters, i.e., about US$3.80/$m^3$.**

8. What is the maintenance interval for ECAR?

We estimate that a community scale ECAR system will needs daily maintenance and oversight that can be provided by a local operator with high-school level formal education. Ongoing maintenance includes 1) removal of iron-arsenic sludge produced during treatment (every few days), 2) monthly equipment check and maintenance including cleaning impellers and oiling small motors used to agitate the solution during treatment, and 3) annual replacement of the electrodes. Long-term field tests (planned for 2012) will further elucidate maintenance requirements.

9. Does ECAR remove both AsIII and AsV?

Yes, ECAR removes both As-III and As-V. This is one of the great benefits of ECAR. Laboratory and field tests repeatedly remove up to 3000 ppb of AsIII and AsV from spiked synthetic and real groundwater samples.

10. Does ECAR work in real groundwater with high levels of phosphate and silicate?

Yes - ECAR has been laboratory tested using groundwater with relevant levels of phosphate and silicate for groundwater in the Bengal region. ECAR has also been tested using real groundwater sampled from arsenic-contaminated wells in western and central Bangladesh, West Bengal (India), and central Cambodia. In all cases, ECAR was able to reduce arsenic to < 10 ppb, and in most cases to < 5 ppb.

11. How much waste is produced per person per year and where would it go?

All arsenic removal technologies produce arsenic-laden waste. ECAR lab tests routinely produce about 80 – 120 mg of dry sludge per liter-treated to reduce 600ppb of AsIII and AsV to below 10 ppb in synthetic groundwater (containing, among other ions, relevant levels of phosphate and silicate). This amounts to amounts to about 300 grams/person/year of dry waste sludge assuming 10L per person per day of clean water.

Field tests produced 0.4L wet sludge per 100L treated, amounting to a raw water rejection rate of 0.4%, using simple settling and decantation techniques to separate sludge from clean, clear water.

US Environmental Protection Agency (US EPA) has a test protocol called Toxicity Characteristic Leaching Protocol, or TCLP. This TCLP testing confirms that ECAR waste is safe for disposal in a non-hazardous US landfill.

Extended X-ray Absorption Fine Structure spectroscopy (EXAFS) on ECAR waste suggests that arsenic is bound to iron by a strong inner-sphere complex, making extensive leaching unlikely.

Alternative disposal routes also exist. Recent studies have shown that 10% of ingredients in concrete can be replaced with arsenic-laden waste without affecting its compressive strength or leaching arsenic in the environment (Banerjee and Chakraborty, Clean Technologies and Environmental Policy, 2005). This method of disposal is currently used in China. The TCLP leachate test was performed on powdered concrete containing 11% ECAR sludge and showed 0 ppb arsenic in the leachate (in addition to passing all other EPA metals requirements).

12. What are the safety issues involved in using ECAR?

ECAR produces arsenic-laden iron sludge that must be disposed of appropriately. The technology uses only low voltage (< 3 Volts) electricity. Note that ECAR does not require the handling of highly acidic or corrosive chemicals for regeneration or cleaning.

13. How will you monitor water quality to ensure that ECAR is working?

In a community safe water center, revenue from water sales could pay for regular monitoring. There are a number of existing and emerging technologies that could be used for monitoring, including the Wagtech Arsenator, or local Atomic Absorption Spectroscopy (AAS) available in some cities. In all cases, assurance of acceptable performance requires long-term periodic testing, and entails some additional costs. In our

opinion, bearing these costs is an important part of delivery of assured arsenic-safe drinking water.

14. Is this affordable and are people willing to pay for treated water?

We believe that people will be willing to pay for arsenic-safe drinking water. However, in practice this remains to be proven for arsenic-free water. (Already there are millions of rural Indian paying a modest amount (2 rupees per 10 liters) for biologically safe drinking water. Much will depend on (1) public education and outreach, (2) public confidence in, and validation of, arsenic removal effectiveness, and (3) the affordability and convenience of the final product.

15. What is the optimal scale for ECAR technology? Can it be made on a household scale?

The optimal scale for ECAR technology is a community scale (500 - 2000 people). This is because the burden of maintenance, operation, arsenic monitoring, electricity supply, and quality control are spread over the full customer base; these burdens do not decrease proportionately as the technology is scaled to a household.

ECAR technology itself can be built for a single household, or even smaller units, and could be powered with a D-Cell battery. The unit price increases significantly with smaller size.

16. How does ECAR treated water taste?

An informal blind taste test with ECAR treated water was indistinguishable from both California tap water, untreated synthetic Bangladesh groundwater containing no iron, and Kolkata groundwater containing minimal iron. We expect the taste to be preferable to real groundwater, which often contains high levels naturally occurring iron. The use of alum coagulant did not affect the taste test results.

MORE INFORMATION

http://arsenic.lbl.gov and references therein

For more technical and scientific information, please review the Physics doctoral dissertation of Dr. Susan Addy. A PDF of the dissertation can be downloaded from: http://repositories.cdlib.org/lbnl/LBNL-1405E/