

A Solar Water Purifier for Converting Arsenic Contaminated, Tubewell Water into Safe, Pure Drinking Water

Introduction

A solar water purifier has been designed, made and tested which consists of carefully designed black plastic sheet covered by a toughened, white glass window. The plastic is formed into an array of square cells which contain impure water laced with arsenic at levels which are about 4x, 8x and 12x the acceptable World Health Organisation (WHO) values of 0.005 mg/Litre. There are no filters, no electronics, no moving parts, no chemicals and cleaning is rarely needed.

It is lightweight, cheap, strong, durable and can be used with a wide range of available dirty water in any sunny location on Earth – no power is needed – Just Add Sunshine.

Tens of millions of people across Bangladesh and western India are currently drinking well water laced with concentrations of arsenic that are likely to kill them eventually. At least half of Bangladesh's estimated 12 million backyard tubewells are thought to be poisoned. Many deliver water with hundreds of times the WHO limit for arsenic in water supplies. (Reference: Fred Pearce "When the Rivers Run Dry" Eden Project Books 2006. ISBN 1903919576/9781903919576)

Water contaminated with Arsenic at 0.01mg/Litre, which is less than 0.2% of the fatal dose, can lead to problems with the skin, circulatory and nervous systems. If arsenic builds up to higher toxic levels then open lesions, organ damage such as deafness, neural disorders and organ cancer, often fatal, can result.

Treating arsenic laced water with the Solar Water Purifier reduces the arsenic level to less than 0.001 mg/Litre (ppm) which makes it perfectly safe for drinking purposes. The measured arsenic level is less than the limit of measurement of the test laboratory (i.e. less than 1 part per billion). The measured results are listed in Table 1.

In addition to purifying arsenic-laced water, the Solar Water Purifier is ideal for desalinating sea-water containing 35,000 parts per million (ppm) of totally dissolved solids (TDS). This is typically converted into potable water with a TDS of 1-2 ppm.

How Does It Work?

Infra-red radiation ($0.7\mu - 2.5\mu$) from the sun is transmitted through the white glass. The water gets hot and vaporizes then individual droplets coalesce forming a "sheet" of pure water which runs down the underside of the glass into a collection channel. The theoretical study of this "sheeting effect" is currently being investigated and will be published at a later date.

The ultra-violet radiation ($0.34\mu - 0.4\mu$) combined with prolonged exposure times proves to be extremely effective for the high killing rates (measured as >99.99% of colony forming units, cfu) of many commonly occurring bacteria.

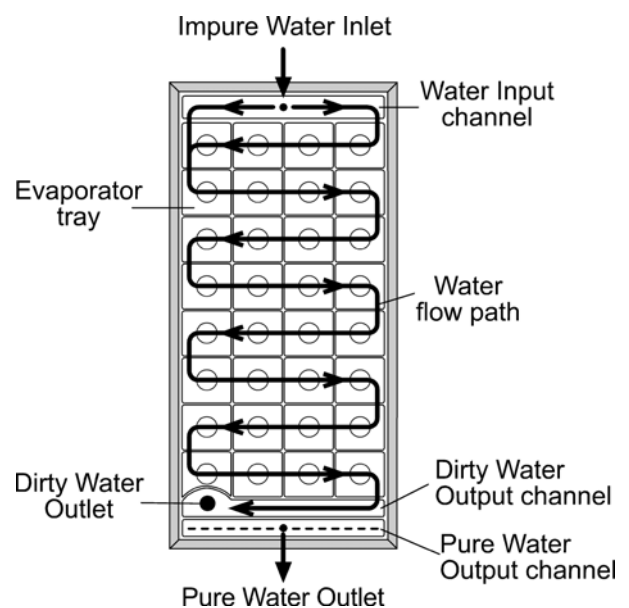


Figure 1: Plan view of solar water purifier showing water flow path



Figure 2: A single solar water purifier and an array of four purifiers

Pure Water Output with Various Kinds of Dirty Input Water

The input water can be tap, bore, grey, sea-water, radio-active, germ or arsenic laced.

When processing grey water, it is necessary to filter out the initial large particles and to finally remove any undesirable residual smells or taints of scented matters, with an activated carbon filter which must be connected in series with the pure water output.

If dirty input water is slowly trickled through the purifier, say at 10-15 Litres/day then hardly any deposits will form in the purifier itself. (This flow rate is about 4-5 times the pure water output rate.)

If unwanted deposits do form, then they can easily be removed by chopping up 4 or 5 lemons, mixing with dirty water, sieving with a towel then filling the purifier with this solution. Leave the lemon juice solution in the purifier for a couple of hours in the sun – rinse in dirty water and the purifier is clean again.

Experimental Results on Water laced with Arsenic

Three sample bottles each containing 5 litres were prepared by the Australian Water Quality Centre at Bolivar in South Australia. The solutions were made up by dissolving arsenic trichloride ($AsCl_3$) in ultra pure water with a TDS of slightly less than 1 ppm. The equivalent arsenic content of each solution was arranged to be nominally 0.02, 0.04, 0.06 mg/Litre or ppm.

These solutions were prepared to ‘NATA’ and ‘WHO’ standards by the Australian Water Quality Centre at Bolivar in South Australia.



Arsenic concentration
0.02 mg/Litre

Arsenic concentration
0.04 mg/Litre

Arsenic concentration
0.06 mg/Litre

Figure 3: Three solar water purifiers containing arsenic solutions.

These 3 solutions were used to fill 3 closely identical solar water purifiers which were set at an angle of 12.5° to the horizontal facing true North. (In the Northern hemisphere, the purifiers would have to be located facing true South.) They were exposed to the sun for the same length of time under identical exposure conditions.

After operating the purifiers for 4 hours at shade temperatures between 25°C and 33°C on 12th February 2007, the 3 clean, sterilized sample bottles were rinsed using water from the 3 pure water outlets.

After rinsing, these 3 bottles were used to collect 250ml samples of the pure output water from each solar water purifier unit.

The 3 x 250ml bottles along with the 3 x 5 litre bottles still containing some of the original arsenic solutions were returned to the test laboratory for a determination of the arsenic content of each.



Figure 4: Showing collection detail

The following results were obtained (*)

Solar Water Purifier	Initial Arsenic Content (mg/Litre)	Final Arsenic Content (mg/Litre) After treatment by the Solar Water Purifier	Comments
1	0.028	< 0.001	Limit of detection for arsenic in this test is 0.001 mg/Litre
2	0.047	< 0.001	
3	0.077	< 0.001	

Table 1: Experimental results of the arsenic content of water before and after treatment in the solar water purifier.

(*) Australian Water Quality Centre Final Report 18144 for Project ‘AWQC-10673’
CSR: ‘122347-2007-CSR-1’

Analytical Method Code TO512-21, Inorganic Arsenic by Hydride Generation

Sampling Method Code W09-023, Sampling Method for Chemical Analysis

NATA accreditation ID, 1115

Conclusion

Levels of arsenic in the test solutions well above the WHO maximum recommended safe levels were reduced to concentrations less than 1 part per billion by one pass through the solar water purifier.

The solar water purifier is an Australian invention which will convert almost any source of contaminated water, including water laced with deadly concentrations of arsenic, into Clean, Healthy Drinking Water – “Just Add Sunshine”.