Looking for safe drinking water?

- *Techniques using free sunshine and rain*

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- Techniques using free sunshine and rain

- a booklet for technology dissemination

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Waterborne Dioarrhoea can kill

Water is life, but if contaminated by germs or poison, it can be a killer. Waterborne diarrhoeal diseases like simple diarrhoea, cholera, typhoid, etc., take away many working hours; these can even kill. Babies and children have less resistance and do not have much reserve of nutrition, therefore death comes quickly when attacked by diarrhoeal diseases.

Arsenic – poison of death in tubewell water

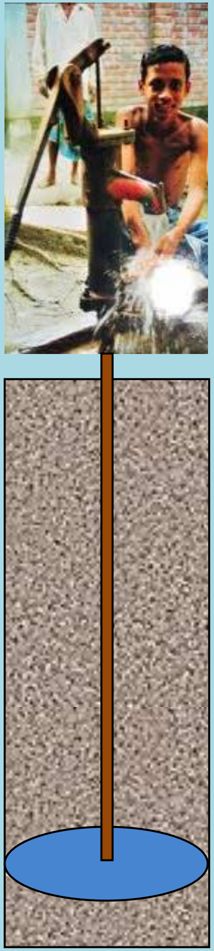
People in Bangladesh used to drink water from rivers, ponds and wells many years back, but because of diarrhoeal germs they switched to tubewell water in the recent times. Now that poison of death 'Arsenic' has been found in water from many tubewells, people have become helpless.

Arsenic disables people and gradually leads them towards death. It causes 'arsenicosis' whose primary symptoms are: skin inflammation, blisters, black spots in palms and soles. If continued for prolonged periods, it may lead to skin cancer, and cause serious harm to lungs and kidney.




Therefore whatever the hurdles are, we have to find safe drinking water.

Not doing it would be unwise.



Which water body has arsenic, and which not?

Arsenic conatamination of tubewell water in Bangladesh occurs for depths between 20 metres and 100 metres approximately (around 70 ft to 300 ft). Deep tubewells are usually free of arsenic though contamination has been found in a few. The presence of arsenic in water cannot be detected through taste, colour or smell. Detection is only possible through complex chemical procedures.

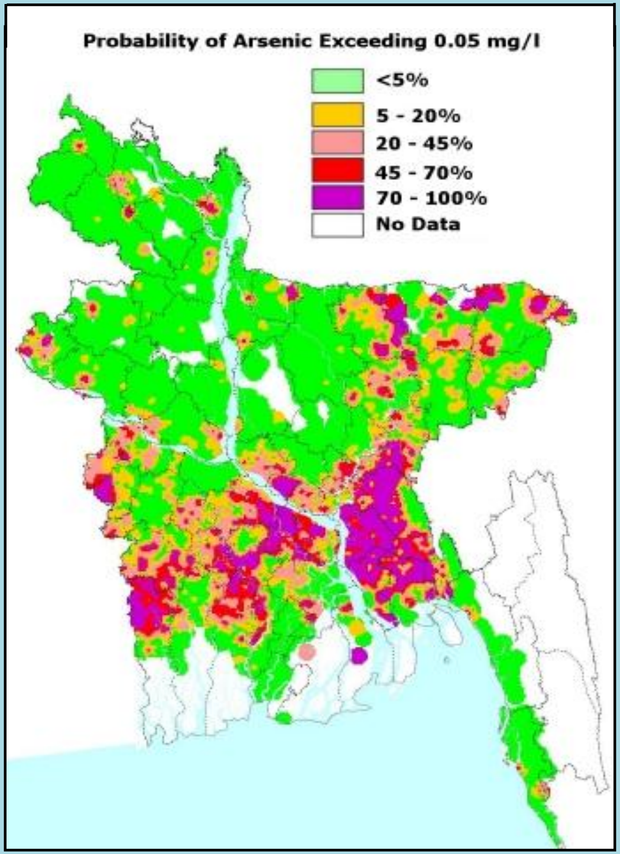
Surface water in rivers, ponds, canals, lakes and wells is free of arsenic because these water bodies are created through accumulation of water from rain or molten snow, with no possibility of arsenic contamination. As the surface water seeps through the ground below, arsenic from different layers of the earth’s crust may contaminate this water, and for this reason arsenic is only found in groundwater. Some scientists think that due to withdrawal of groundwater, air has gone into the underground aquifiers and oxygen in this air has caused chemical reactions to produce soluble forms of arsenic. This dissolved arsenic compound is the source of contamination. Some scientists think that soluble arsenic has been produced through reactions caused by microorganisms living in the underground aquifiers.

Devastation of arsenic contamination in Bangladesh

Overall, water from almost one fifth of tubewells in Bangladesh is arsenic contaminated. However, in certain areas almost 90% of the tubewells are contaminated. The map next shows the extent of arsenic contamination in Bangladesh.

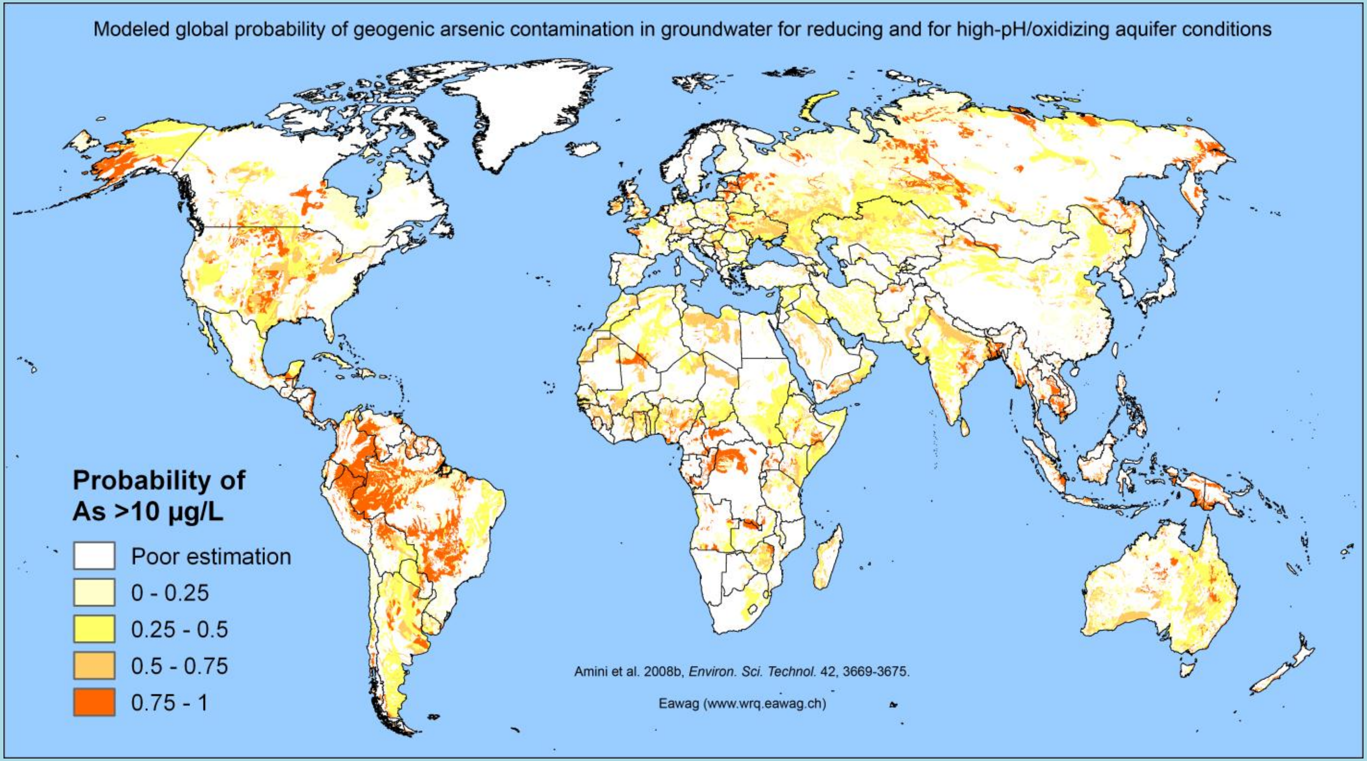
Similarly arsenic contamination exists in many other parts of the globe too as the map in the next page shows.

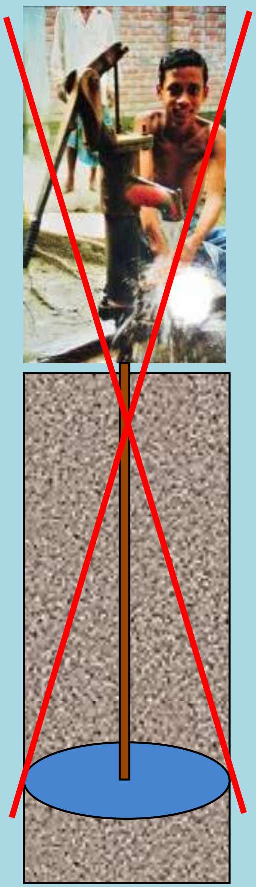
Whether due to arsenic, or due to contamination of diarrhoeal germs, a large global population cannot get safe drinking water, and we need to do something about it urgently.



Map showing modeled global probability of arsenic contamination of ground water

(Amini et al. 2008, Environ Sci Technol, 42:3669-3675)



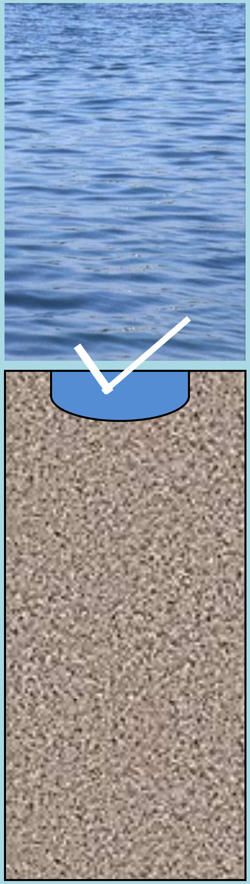


Arsenic removal is difficult, but destroying diarrhoeal germs is easy

Since arsenic occurs as a dissolved chemical compound in water it is very complex and expensive to remove. Some filters can remove arsenic from water but the removed arsenic accumulates in the filter element in a concentrated form which has to be replaced periodically. If this element is thrown away carelessly, which is highly possible with widespread use of such filters in the rural areas, dangerous contamination of surface water and plants may happen, from which we may not find an easy way to come out.

On the other hand destroying diarrhoeal germs is easy, Just boiling water destroys all diarrhoeal germs, and in this booklet we present some innovative methods using free sunshine.

Therefore, the best course would be not to bring up the poison that lies buried under the ground. Rather it would be wiser to use easily available surface water from rivers, canals, ponds, lakes and wells which are arsenic free by destroying diarrhoeal germs.

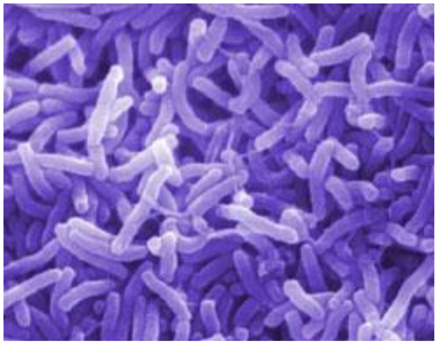


Diarrhoeal Germs in surface water

- but can be destroyed easily

Surface water, that means water of rivers, canals, lakes, ponds and wells are free of arsenic, but these are contaminated by diferent kinds of microorganisms. However, not all of these are harmful for humans. The ones that are include germs of diarrhea, cholera, typhoid, para-typhoid, hepatitis-A, etc. Excretion from humans and animals are responsible for such contaminations.

90% of all child deaths occurring in developing countries like Bangladesh are caused by diarrhoeal diseases, spread through contaminated water. The death rate can be reduced significantly simply through disinfection of drinking water. For adults frequent diarrhea takes away working time, and family income is reduced. Death can also happen in some cases. Therefore, disinfection of drinking water is of prime importance, and it can be done easily.



Solution:

Use surface water from rivers, canals, ponds, lakes and wells

- ***these do not have arsenic, and***
- ***it is very easy to disinfect such water***

Disinfecting water of harmful diarrhoeal germs is much easier than removing arsenic from water, and this can be done in each home, even in the rural areas. One does not need to take up large expensive projects for this. Therefore it would be wise to disinfect surface water collected from rivers, canals, ponds, lakes and wells. This message needs to be spread far and wide to everyone.

Rainwater is also safe to drink

Rainwater is basically distilled water and is therefore, pure. However, in the intial few minutes of a shower, floating germs and dust in the air will be mixed up with the water. Therefore, we need to avoid these first few minutes of rain. By collecting good amounts and storing it carefully, we can provide drinking water for the whole family for many days.

The curse of ignorance

The ladies who are rowing hard to fetch drinking water from a distance do not know that the rainwater drenching down their bodies is pure and could be collected easily in large amounts to provide drinking water. They do not know that the lake on which their boat floats could be rendered safe for drinking by destroying diarrhoeal germs very easily.

The flood affected people do not know that they could make the flood water drinkable by easily destroying diarrhoeal germs. Had they known the techniques they could have disinfected flood water on the raft itself using sunshine. They could have made a gadget on the raft to collect plenty of rainwater for drinking.

Learn techniques to obtain drinking water under any situation

Normally all diarrhoeal germs in water are destroyed by boiling. However, in many situations it becomes impractical due to fuel scarcity. Particularly during floods it becomes almost impossible. The good news is, we at Dhaka University have innovated some simple technologies for disinfecting water using free sunshine, which is free for everyone to use! This booklet describes these techniques in detail. You can use these descriptions to make very low cost gadgets at home using materials widely available in the market. Scientific explanations have also been given so that you may improvise alternatives in case the specified materials are not available at your place.

Rainwater is pure and is drinkable straightway. Some of our innovations for collecting reasonably large amounts of rainwater, again using simple techniques have been presented in this booklet.

Scientific facts behind destruction of diarrhoeal germs in water by heat

Raising water temperature to 60^0C and maintaining it for 30 minutes destroys all diarrhoeal germs in water. This includes germs of Cholera, typhoid, paratyphoid, etc. This is also the technique for pasteurization of milk. Relevant data, collected from scientific papers are presented in the table below.

The germs are destroyed at much shorter times if the temperature is higher. For example, at 70^0C, only 15 seconds (yes, seconds, not minutes!) are needed. Water boils at 100^0C, which is still higher, and you can easily guess that at this temperature what you will need is only a fraction of a second. You do not need to boil water for 20 minutes as commonly publicised. Tetanus spores are not destroyed at 100^0C, even with hours of heating. Besides these are not harmful if you drink. Tetanus spores have to get in contact with blood to cause any damage.

Germ	Disease	Destruction (temp, time)
Salmonella	Typhoid, Paratyphoid	60^0C, 20 mins
Vibrio Cholera	Cholera	55^0C, 30 mins
E-Coli	Diarrhoea	60^0C, 20 mins
Shigella	Dysentry	55^0C, 60 mins
Rota Virus	Child Diarrhoea	60^0C, 30 mins

How would you destroy germs in water from rivers-ponds-lakes-wells?

The first step: *filter out floating dirts*

Filtering out all floating dirts, algae, etc. should be the first step. You may do it using a piece of cloth tied to the mouth of a bucket as shown in the photograph. Taking a close-knit cloth is advisable. It will take more time to filter, but it is better. Just leave the water on the cloth filter. Clear water will be collected in the bucket over time. If the cloth is not thick, take several folds of it.

If the water is too murky, use a bit of alum which will help to settle down the fine soil-particles as sediment below. You may use crushed seeds of a plant called 'Moringa', if it is available, as an alternative to alum. Removing the covering of dried moringa seeds, crush these and sieve to collect the fine powder. Pour half a teaspoonful of this powder into 20 litres of water and keep stirring for 15 minutes. Leave it undisturbed for a few hours. The dirt will settle down as sediment. Pour off the clear water from the top slowly.

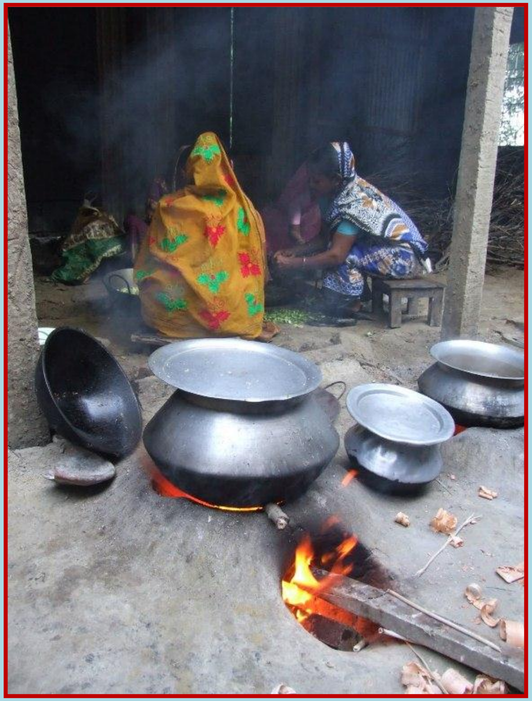
The second and final step: *Boil water*

--- So simple!!

You kill two birds with one stone. The problem of arsenic is solved by going for surface water which is free of arsenic. Again, you destroy all diarrhoeal germs in this surface water by simple boiling, the technology of which is within your own grasp. You don't have to depend on anyone else, or on any supply of materials from outside. Know further that it is not necessary to boil water for 20 minutes as often said. Just taking water to the boiling point is enough.

Spread this information to everyone!!

If the solution to arsenic contamination of water is so simple, you may wonder, why has not it been promoted before? In this age of commercial interests, no one gets any monetary benefit by publicizing such information. This is partly the reason behind.



Destroy diarrhoeal germs using 'free' sunshine

However there are occasions when you may not be able to boil water either due to scarcity of fuel, or due to difficult situations, such as during flood, or after a natural disaster, when burning a fire would be almost impossible. In such situations you may heat up water using free sunshine from nature, or you may collect more of rainwater which is pure and drinkable. This booklet informs you how to do these things using simple everyday materials.The table presented in page 11 shows that all diarrhoeal germs in water are destroyed in half an hour at 60^0C. This is the famous Pasteurisation process. We have been able to raise the temperature of water to more than 60^0C using sunshine by innovating simple gadgets out of easily available materials. In Bangladesh summer we achieved 80^0C while in winter about 65^0C. Through microbiological tests the destruction of diarrhoeal germs were confirmed. In this method the water also gets ultraviolet rays from the sun, as a result diarrhoeal germs have been found to be destroyed even at lower temperatures of 50 to 55^0C.

To know how to do this yourself, see the pages that follow.

How to destroy diarrhoeal germs using sunshine

- using our innovative methods

(alternatives have been presented later)

Materials needed, for the basic model:

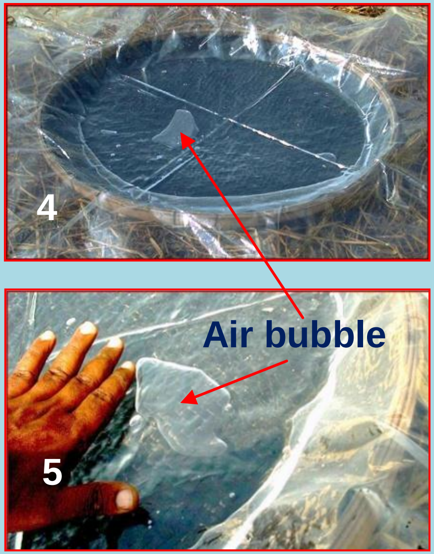
1. Hay (paddy straw/grass straw): about 1½ kg.
2. A bamboo tray about 75 cm in diameter, painted black inside using enamel paint (or a similar circular or square tray made of any other material, including plastics or metals).
3. Four transparent and thick polythene sheets each at least 40cm larger than the diameter of the tray. Transparent polypropylene is still better.
4. Some heavy weights to press onto the polythene sheets outside, to keep them stretched.

Setting up of the water disinfection gadget

Step by step instruction

- the basic model: using polythene sheets

1. Spread the hay to a thickness of at least 10cm and place the bamboo tray on it (Fig.1). The hay bed prevents heat from escaping below.
2. Have the water filtered and/or sedimented to remove floating dirts and particles as described before.
3. Clean all the polythene sheets well.
4. Spread the first polythene sheet on the tray and pour water to a depth not more than 2cm (Fig.2). The water will heat up more quickly if the depth is less. In a tray with 75 cm diameter, about 5 litres of water will make the specified depth. You need to ensure the same depth of water on all sides (Fig.3) by adjusting the hay below.



5. Now spread the second polythene sheet so that it touches the water surface everywhere. If there is any air bubble as in Fig.4, remove it to the sides by light push with a finger as in Fig.5. Otherwise water vapour will condense at the bubble and will block sunshine.

6. Now spread a few strands of straw (Fig.6) and spread the third polythene sheet on top (Fig.7). A a layer of air is necessary between the 2nd and the 3rd sheet to prevent the escape of heat upwards, and the strands of straw are used to ensure that the sheets don't touch anywhere. Do not put too many straw strands as these will block sunshine.

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7. Similarly spread a few strands of straw on the 3rd sheet and spread the fourth and the final sheet on top (Fig.8). Again, the straw strands are to prevent the 3rd and the 4th sheets from touching.

8. Now to keep all the sheets stretched taut, put some weights on the polythene sheets on the outside of the tray (Figs.9). If necessary you may make a ring of a thick rope out of straw (Fig.10) or jute (Fig.11) which may be used as the weight. In a clear mid-noon sunshine, it will take about 1½ to 2 hours to heat up the water to more than 60^0C, and thus to destroy the diarrhoeal germs.

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9. Remove the top three polythene sheets and gather the edges together of the bottommost sheet to gather the treated germ-free water as shown (Fig.12). Now pour the treated water carefully to a storage pitcher or water tank. Take care so that your hands do not touch the water, nor the fourth sheet that holds the water, particularly in the area through which water will be poured out. Our hands always contain some germs and will easily contaminate the treated water. As a precaution, it is a good practice to wash hands well using soap before pouring thr water.

The basis of this water heating is the famous “Green House Effect”, and the innovated gadget is basically a solar flat plate collector. However, the main challenge was to raise the temperature to such high levels using cheap and easily available materials. The whole contraption will cost about US $2, and with careful use, the materials will last many days. If the polythene sheets get leaky, you may close the small holes using sticky tapes, or seal a hole by folding the place and heating in a candle flame. Use these repaired sheets as the top two sheets in our contrivance, which do not come into contact with water.

Comments:

Under a clear sky, if there is strong sunshine as in the tropics, water will be disinfected in about 1½ to 2 hours using our innovated gadget. This you may get done twice, between morning and afternoon, disinfecting about 10 litres per day using a single unit. If there is light cloud, increase the time, say about 3 to 4 hours, or decrease the amount of water to have less depth. However, do not use this method if the cloud cover is continuous. Therefore, disinfect more water than necessary during the periods of clear sunshine and store for such periods.

If there is rain, collect more of it using ideas presented in this booklet later, and store properly for future use.

In place of the black paint in the above tray, you ay use black plastic sheet or a black piece of cloth. However, do not use the black plastic sheet to hold the water since most of the black plastic sheets are recycled from waste plastic and may contain ingredients that are harmful to human health. At high temperatures such ingredients are more likely to come out of the plastic. Therefore only use polythene or polypropylene as the sheets which come into contact with water. These materials are safe for health.

By spreading a white cloth vertically on the side against that of the sun, you may reflect some more energy from the sun onto the device, and thus hasten the disinfection process.

Alternatives:

Using large polythene/polypropylene bags

The job is easier if you can get hold of such large transparent bags. However, to ensure that the depth of water is no more than 2 cm, fill up only one third of the bag and lay it down on the blackened tray with the open end placed over the raised edge of the tray as shown. If there is air bubble inside, remove the air to the open end as before with a light push of the fingers. Now to create the two enclosed air layers on the top, use two polythene sheets as before, but place a few strands of straw in between.

When done, pour the water into a clean storage tank or pitcher.

Polypropylene is more transparent than polythene, and does not becoe soft when heated, so is better than polythene.

Alternative for bamboo tray

If bamboo tray as shown is not available, anything which is flat and rigid can be used. It can be a bamboo mat, a plastic mat, or even a metal sheet. Only a raised edge, about 3cm high, on all sides is necessary. This can be improvised using many things, including a sliver from a length of bamboo, a thick rope made of straw, or simply using clay.

Using small polythene bags

- Easier to distribute during disasters

Several small polythene bags may also be used to disinfect water. To keep the depth of water to less than 2cm, fill the bag to one third and then twist the remaining part to expel all the air as shown. Finally tie up the open mouth into a knot and lay the water filled bag on the blackened tray. You may have several of these bags in a single tray. Now spread two transparent polythene sheets on top as before, with a few strands of straw in between to maintain the air layers.

Our hands usually carry a lot of germs. Since water in these tied up bags do not have the chance to come into contact with our hands after the treatment, the water can be safely stored for many days, even months. Therefore treated water in these bags can be distributed to people in disaster stricken areas.

High density polythene bags, being thin and malleable, is more appropriate for this technique.

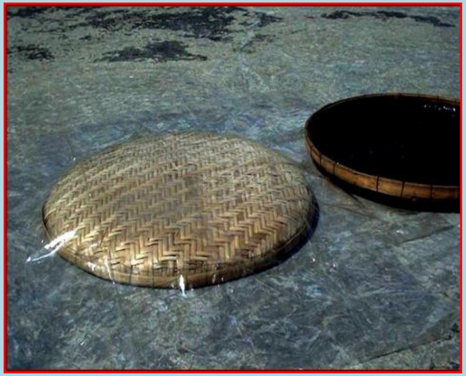
Disinfect water in just a small bag!

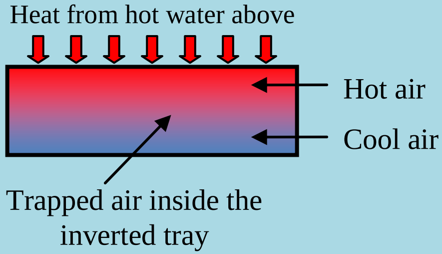
You may disinfect water using sunshine even using a single polythene bag, without a tray. Spread a black polythene sheet or bag on a bed of hay. Now lay the small bag with partially filled water as in the previous page onto the black sheet. Place a few strands of straw (you can also make loops as shown) on top. Now take a slightly bigger transparent polythene bag, put a few strands or loops of straw inside, blow some air into it, and use it to cover the whole of the water filled bag on all sides as shown. To keep it down and to keep the air in, place two sticks on it, one on the open end, and one on the opposite side, as shown. You may also use two polythene sheets as before.

You may thus disinfect a little amount of water in emergencies.

Alternatives to hay-bed

If you don’t get hay, just invert a bamboo tray as shown and spread a polythene sheet to trap the air inside. The trapped air will act as a heat insulator. Place the black painted tray on top and do as before. However, the inverted tray may sag in the middle due to the weight of water, so place a small hard object underneath, just at the middle to prevent this sagging.





How does trapped air prevent heat loss?

In this application, the top layer of air under the inverted tray is heated due to the hot water in the tray above (heated by solar energy). Since hot air is lighter than cool air this hot layer remains in the top and does not mix with the cool air below. Thus there is no convection. Since air is not a good conductor of heat either, therefore, in this case heat from the water does not get lost through the base below. In the figure, red has been used to represent heat and blue for cooler regions.

Some more alternatives to hay bed

The purpose of the hay bed is to prevent heat loss through the base. The hay bed traps air in many minute pockets. Since air is a bad conductor of heat, this hay bed as a whole is a bad conductor of heat. Therefore, do not place the water tray straight onto the ground or on anything solid, because it will lose more heat through the base and the required high temperature cannot be obtained. If you do not get hay, use anything like dried leaves, grass, water hyacinths, jute-sticks, cork or similar soft materials that trap here in minute holes.

Here is another alternative. Blow a little air into many small polythene bags and tie knots to close the open ends. Now put all of these into a large bag to make a bed of trapped air.

You may also put the hay into a large polythene bag. This will allow easier setting up of the gadget daily.

Single alternative to both hay bed and tray

If you can get hold of a large piece (about 50cmx 50cm) of polystyrene foam (as used in packing) at least 2cm thick, the job is easily done. This foam is good for heat insulation as it traps air in myriads of small pores.

Cut out four long pieces, about 2 to 3 cm in width from all the four sides of the foam sheet. Now fix these pieces on the main piece using small thin sticks like tooth-picks to form raised edges on all sides as shown. This will replace both the hay-bed and the tray.

Now spread a black plastic sheet or a black cloth on the foam sheet bed. Now repeat the procedure as before, either using 4 polythene sheets, or large bags and 2 polythene sheets.

The picture shows water in a large bag. Here folded paper has been used to replace strands of straw in between polythene sheets to maintain the air layer separation.

Alternative for straw strands to maintain air gap

We used straw strands before to ensure that the polythene sheets on two sides of an air layer do not touch each other in the middle (top picture). Some alternatives are shown in the lower pictures. You can make rings of thick paper or cardboard, attaching the ends together using glue or staples. You can also make rings of straw, or fold ordinary writing paper in zig-zag fashion. The main idea is to maintain an air space between the polythene sheets, but not using too many of the spacers since these will block sunlight.

How is water heated by sunshine? - Scientific explanation

It has already been said before that the basic technique is the famous “Green House Effect”. In the cold countries people make glass houses, inside of which are warm while the outside may be freezing. This they do to grow green vegetables, therefore the name, “Green House”. In our innovation we have used cheaper and unbreakable transparent polythene sheets in place of glass.

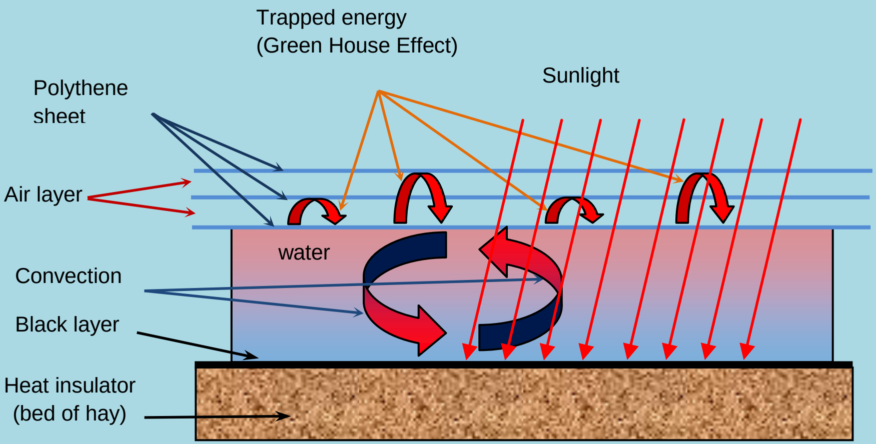
How does Green House Effect work?

Solar energy that we receive is basically in the form of electromagnetic waves with a large range of wavelength, ultraviolet - visible - short infrared - long infrared. Polythene is transparent to the visible and the short infrared part of the solar radiation. Therefore solar energy within this part of the spectrum goes through the polythene and water down to the blackened bottom of the tray. The black layer absorbs all the energy and gets heated up, which in turn heats up the water. Now the heated water in turn gives out energy through long infrared radiation to which polythene sheets are not transparent, i.e., these sheets appear opaque to this radiation. Therefore, this ‘radiated’ energy from water cannot come out and is trapped. Through continuous collection of trapped energy the water temperature keeps going up till it is balanced by heat lost by the system. This is ‘Green House Effect’ and is shown schematically in the figure on the opposite page.

How does the whole bulk of the water get heated? The heated black layer of the tray heats up the bottom layer of water that is in its contact. Hot water is lighter than cold water, therefore this hot water rises and cold water from the top sinks, which gets heated as it comes in contact with the black surface below. The hot water at the top cools by losing heat to air above and becoming heavier, comes down, again to get heated up at the black bottom. Thus a loop current builds up and the whole of the water heats up. This process is called ‘convection’, and is also indicated in the figure.

The hot water cannot lose heat by ‘radiation’ as mentioned above, but loses heat through other processes called ‘conduction’ and ‘convection’ to the outside environment. The temperature to which the water can be raised depend on the balance of the heat gained and heat lost. Therefore with stronger sunshine, more heat will be gained, and higher will be the temperature. Again, more heat loss will result in decreasing the temperature. Therefore, our target is to minimise heat loss through these two other processes. To prevent heat loss through conduction to the ground below, we have placed the hay bed, which, because of the trapped air pockets, is a good insulator of heat. On the top side, had there been nothing above the hot water, it would have lost heat quickly through ‘convection’ in the air above (air heated by hot water would rise up and cool air would come down forming a loop, similar to that described above for convection in water). Since we also need sunlight to come from the top, we have a difficult situation. We have minimised heat loss by creating two thin layers of air using the 3rd and 4th polythene sheets (using some straw strands to prevent the sheets from touching).This is how we have minimised the heat loss to achieve the required high temperatures. The 2nd polythene sheet touching the water surface is required to prevent water vapour from condensing in the form of water droplets on the polythene sheet above, which would have blocked sunlight.

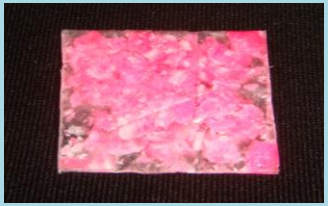
In this arrangement sun’s ultraviolet radiation also enters and acts as an additional agent to destroy germs.

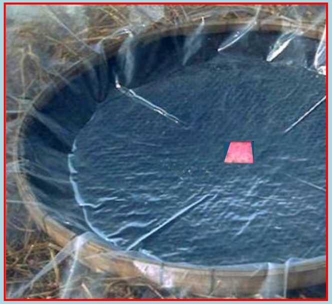


How to know if requisite temperature was achieved?

- a maximum recording thermometer

Normally in clear and strong sunshine water will be heated to the requisite temperature. However, if we want to find out, we can devise a low cost indicator, which acts like a maximum recording thermometer. Make a small bag, about 3cm square, using transparent polythene. Crush some coloured wax from a candle and insert into this bag. Seal the open end. You can do it by folding the end and heating the fold-line in a candle flame, or you can just staple the folded end. Place it just above the 2nd polythene sheet described above, which just touched the water surface. Do the rest of the steps as mentioned before. Wax melts at about 55^{0}C, and if the water reaches this temperature, the wax in the bag will melt making it almost transparent. This can be understood even if the water cools down later. By twisting the bag the molten and solidified wax can again be crushed to a powder, and reused. (The idea to use wax as a maximum recoding thermometer was innovated by CMES, a local NGO. However, the idea to put it in a polythene bag for repetitive use is ours)





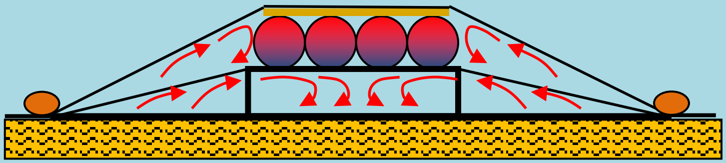
Using a PET water **bottle** – our innovation

We have developed a technique to use now widely available PET water bottles to heat water using sunshine, and thus destroy diarrhoeal germs. However, in contrast to the techniques described above, the depth of water is more here, therefore, we need a slightly different technique. Firstly make a frame of thick galvanised iron wire as shown in the top picture, on which 3 or 4 bottles canbe laid down sideways. The bottle has been shown just to show the size needed. Take care that the ends do not protrude anywhere. We bent a single wire to make the frame and the two ends were joined at one side of the bottom, and were concealed by wrapping a plastic tape around.

To set up the heating contrivance, place the frame on a blackened tray, which is placed on an insulating bed of hay, as before. However, in this case you do not even need a tray, just spreading a black plastic sheet or a cloth on the hay-bed would do. Now cover the whole tray and the frame using a transparent polythene sheet (1^{st} sheet). Fill up three or four 1 litre PET bottles completely with water and screw the covers tight. There should not be any air bubbles inside. Now place the water bottles on the frame (above the 1^{st} polythene sheet) as shown in the middle picture and spread a few strands of straw on the bottles sideways. Cover the whole assembly using another (2^{nd}) polythene sheet and press down on the outside with weights to keep the sheets stretched taut. Water will be heated to 60^0C in about 2 hours.

Do not use very old PET bottles, particularly if there are crack marks, or if the bottle gets dull as these give out some chemicals hazardous to health. Do not use coloured bottles. Use only transparent colourless bottles.

Explaining the heating process



Here the water in the bottle is indirectly heated by the trapped air first. We have created two air chambers using the two polythene sheets as shown.

The black cloth (or plastic sheet) on the hay-bed absorbs sunshine and gets heated, which heats the air in the lower chamber. Because of the slope created by the polythene cover, the heated air goes towards the bottom of the bottles and transfers heat to the water, getting cooler in turn. This cold air comes down and moves towards the sides where it gets heated again, traveling back towards the bottle. Thus a continuous convection loop builds up heating the water at the bottom. The water in the bottle again distributes this energy through convection and heats up the entire mass of water. The upper chamber created by the 2nd polythene sheet primarily insulates the lower air chamber from the cold atmosphere, but takes away some heat from the lower chamber as well. Here the warmed up air moves towards the bottles where it transfers heat to the water, cools, comes down, warms up again, forming another convection loop. To prevent heat loss from the top of the bottles to the atmosphere we have placed some strands of straw on top of the bottle, to create an air gap. Thus this arrangement uses up the solar energy as much as possible to heat the water in the bottles.

It may be possible to increase the temperature by having another polythene cover on top, again separated from the lower sheet by a few strands of straw. Making the base area larger one can gather more heat energy from the sun. Using transparent bottles will allow ultraviolet rays to contribute further to the destruction of germs.

Collection of Rainwater, domestic scale

Rainwater is pure distilled water and is safe to drink if collected properly. In the early few minutes of a shower, it will contain dust and germs floating in the air, therefore, one should wait for five minutes or so before collecting rainwater. To collect in large quantities there have been suggestions to use the slanting tin roof of a rural house. However, it is not very practical since there will be bird droppings, rotten leaves, etc., on the roof. We have suggested the use of polythene sheets which you can clean and store easily, and put to use quickly when it starts to rain. Collect more than your immediate needs and store for future use.

For such quick installation, erect a permanent square frame using bamboo or wooden sticks as shown in the top picture. Keep the top ends of the vertical sticks stand out a little above the junction. Take a square piece of polythene a little larger than the square frame and cut a round hole, about 3cm diameter, at the centre of the sheet (middle picture). Now tie loops of ropes or tapes at the four corners of the square polythene sheet. Now slip the loops onto the protruding top ends of the vertical sticks. Keep a bucket under the hole at the middle. Water will collect into the bucket when it rains.

You can also do away with the central hole by fixing the polythene sheet as a funnel as shown in the top picture. The sticks in the front have to be fixed closer together as can be seen in the picture. Water will collect into the bucket placed below.

Take care that the jig is not fixed under a tree, otherwise dirts will fall from the tree into the collected water. You should have open sky above the jig.

Collecting rainwater using cloth

In the first technique above, you can use a cloth in place of the polythene sheet, but without the hole in the middle. Just place a clean stone or a weight in the middle to make the cloth dip at the centre. The cloth will collect rainwater in the middle so that water can fall into the bucket below. You get filtration at the same time. However, the cloth should have a thick knit otherwise water will fall at all places around. People in some coastal areas in Bangladesh used such methods many decades back, but are forgotten now.

During floods

All the techniques we developed can be installed on a raft during floods, so these can be used as a part of the disaster preparedness plan of a family. You can use flood water itself. Filter it using a cloth and destroy the diarrhoeal germs in it using the solar technique we presented in this booklet. During rains you can erect the frame for rainwater collection on the raft again.

During disasters:

All the techniques described can be a part of a disaster management programme. If each family stores the items needed in a safe place, they can use these during and after the disaster. Again volunteers can disinfect water using the small polythene bag technique and distribute these to the affected people.

Final words

It does not need any saying to emphasise the importance of safe drinking water. Many years back people used to drink water from rivers, ponds, and wells. However, this was associated with the risk for diarrhoeal diseases, but not much campaign was made to make people boil the water. Rather they were made to switch to tubewells through large scale campaigns with the expenditure of a great deal of resources. Expenditure for fuel is usually raised as a plea for not going into a campaign for boiling water, but we should remember that every family manages to get fuel to cook food. If we could create a mindset that whatever the cost, we need to allocate some fuel to boil water, this could have solved the problem much earlier. Unfortunately it has not happened.

Now that the killer poison Arsenic has raised its fangs in the tubewell water, we need to go back to the surface water, the water from rivers, canals, ponds, and wells with which we once were used to. There are not many industries in rural areas of the Third World, so the surface water is mostly free from industrial waste. Pesticides applied in agriculture can be a problem, but again a campaign can limit the spread of such pesticides, so that the water bodies are kept free of the pollutants. We can have reserve ponds or dug wells in every village with raised banks, specially for drinking water. By boiling this water, or destroying the diarrhoeal germs using free sunshine, the rural people can themselves solve their problem of safe drinking water. We should also spread the words for collecting rainwater using the simple techniques described in this booklet.

Sometimes we find that people get engrossed in seeking solutions in complex ways when simple solutions are there but get overlooked. Millions of dollars have been spent in looking for a solution to arsenic in ground water, but no simple solution has come by so far. Those that offer some solution tend to make people dependent on others, which cannot sustain in the rural environment of the Third World. Sometimes complex solutions come as big projects which are not economically viable unless done in a big way, through big projects. Such big projects somehow do not work out well for the simple village folk in the Third World countries like Bangladesh. They run only for a few months, till an interest for its novelty continues. Again if something goes wrong, either nobody can repair it, or who will pay for the expenses keep the decision hanging for eternity.

A sustainable solution can only come if the technology and supply of materials is within the grasp of the common people. All research and development efforts of our department is geared to this direction. The technologies that we have presented in this booklet can all be done by rural people at home, using materials available around their house or in the local markets. Besides, each family is worried about its own interest, therefore such family based solutions may work out better than community based ones, we believe. If the common people can solve their need for safe drinking water from the information given in this booklet then we will feel that our efforts have been rewarded. If any one wants our help in regards of the technologies presented in this booklet, we will be happy to do it as much as we can.

We, the educated group, have immense responsibility towards the common people in our respective countries, particularly to the majority people living in the villages. These people have undertaken huge sufferings and immense sacrifices just to create the opportunity for a few of us to become educated well, with the hope that one day we will be able to pull them out of the miseries. They have kept themselves half fed to make a few of us well fed, but even in this twenty first century they are deprived of almost all modern amenities of life. It was the responsibility of ours, whom the common people have arranged to get educated in modern science and technology, to deliver the benefits of modern science and technology to their doors, but we have not even been able to provide safe drinking water for them till now. Therefore, our appeal to all educated people in the Third World will be to use the information in this book to teach and train the common people in their respective countries to improve their quality of life a little, to prevent their children from getting killed by diarrhea, to save their people from the curse of arsenic. Again, many lives could be saved during after disasters – whether natural or man-made. By doing this they would be carrying out their responsibilities a little, and feel the satisfaction of being a human being.

CAUTION!!

If you dump waste polythene it pollutes the environment and your interests will also be harmed. So DO NOT throw waste polythene anywhere. Arrange to collect the waste polythene from all members in your village, and arrange to send these to polythene industries for recycling.

Acknowledgements:

Many students worked on this project on water disinfection and rainwater collection at the University of Dhaka with Professor K Siddique-e Rabbani, the department wants to thank them all.

Our team taught the scientists of Centre for Mass Education in Science (CMES), an NGO in Bangladesh, the innovative solar water disinfection technique in late 1980s. Subsequently CMES was successful in disseminating this technique to river gypsies in an area of Bangladesh. Use of scraped wax for recording the maximum temperature of water was an innovation of CMES, although putting it in a sealed plastic sachet for repeated use was an innovation of ours. So CMES deserves special thanks from our department.

Many photographs reproduced in this manual were downloaded from free information sites available over the internet. We want to thank all the sources of these photographs.

Finally the department would like to thank UNESCO for providing the necessary funds for dissemination of the technologies involved, and for preparing this manual. Bangladesh National Commission for UNESCO (BNCU) of the Minitry of Education, Government of Banglasesh, deserves special thanks for acting on behalf of UNESCO and providing all necessary support.

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