

# Household Water Treatment for Fluoride Removal Factsheet: Bone Char Filter

## Potential Treatment Capacity

Very Effective For:	Somewhat Effective For:	Not Effective For:
<ul style="list-style-type: none"> <li>• Fluoride</li> <li>• Taste, odour, colour</li> </ul>	<ul style="list-style-type: none"> <li>• Turbidity</li> <li>• Other Chemicals</li> </ul>	<ul style="list-style-type: none"> <li>• Bacteria</li> <li>• Viruses</li> <li>• Protozoa</li> <li>• Helminths</li> <li>• Hardness</li> </ul>

## What Is a Bone Char Filter?

Bone was one of the earliest media suggested for fluoride removal from water. It was not widely implemented due to the bad taste of treated water, the high cost and unavailability. But in 1988, the WHO claimed it to be an applicable technology for developing countries.

Bone char is a blackish porous granular media capable of absorbing a range of contaminants. The bone char grains are packed in a filter (bucket, drum or column) and water flows through.

Bone char is made from animal bones that are charred (burnt) and crushed. Correct preparation of the bone char is essential to ensure good fluoride removal and to avoid unattractive taste, colour and odour in the treated water. Decades ago, bone char was industrially produced and widely available, but now the supply is limited. However, bone char grains can be produced locally by communities.

## How Does It Remove Contamination?

Major components of bone char are calcium phosphate, activated carbon and calcium carbonate. Fluoride is removed from water through a process based on ion exchange. When raw water containing fluoride comes into contact with bone char, the fluoride ion changes places with the carbonate ion in the bone char, and the fluoride becomes “stuck” to the bone char.

Bone char has high fluoride removal efficiency, and can also absorb a wide range of other contaminants. The fluoride adsorption capacity is 2mg fluoride per gram of bone char (Albertus, 2000).

## Operation

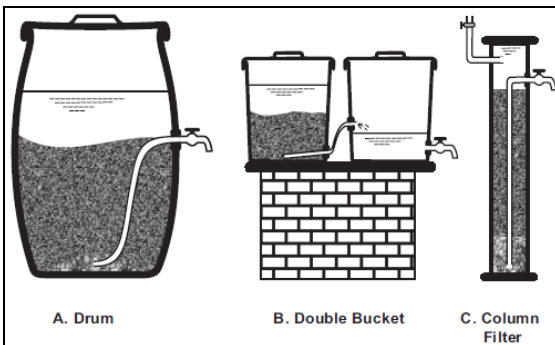
### Bone Char Production

The steps for preparing bone char are: charring, crushing, sieving and washing/drying.

The colour of the charred bone is a simple way to determine its quality (Jacobsen and Dahi, 1997):

- Grey-brownish: Highest fluoride removal
- Black: Still contains organic impurities causing odour and colour
- White: Reduced fluoride removal capacity

Bone char from any animal needs to be carbonized at a temperature of 400 to 500 °C with a controlled air supply. Then the charred bones can be crushed manually or by using a crushing machine. Particles between 0.5 mm and 4 mm can be used as media.



Three Common Households Units for Sorption  
Defluoridation (Credit: WHO, 2006)

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If bone char is not prepared properly, it may result in low defluoridation capacity and/or lower water quality.

## Filter Examples

Bone char media can be used in different kinds of filters. One example is a 20 litre bucket with a tap fixed at the bottom connected to an outlet pipe. A perforated plate can be placed on the surface of the media to avoid disturbance during addition of raw water. The use of bone char alone is efficient with a flowing system, but is not effective in a batch method (Larsen, 1993).

The water level in the filter should never drop below the top of the bone char. If the bone char is left dry, its adsorption capacity will decrease. The water should be in contact with the bone char for a minimum of 20 minutes. The filter can be combined with a ceramic candle to remove microbiological contamination as well (see picture). For new filters or after changing the media, the first few containers of treated water should be discarded due to high turbidity and colour (CDN, 2006).



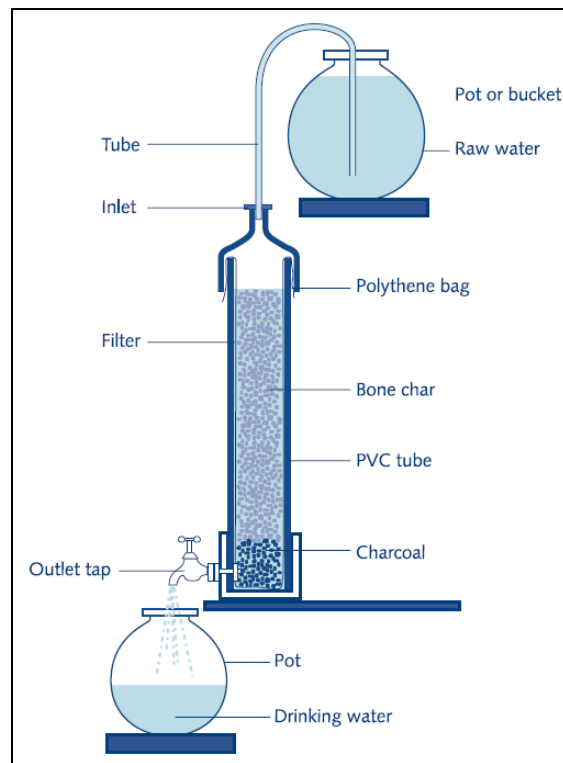
Single and Combined Bone Char Filter  
(Credit: Eawag, 2006)

## Media Regeneration

Bone char media needs to be renewed or regenerated periodically. Regeneration can be done using caustic soda (NaOH). The fluoride concentration in the treated water needs to be measured periodically to know when to replace or regenerate the media. However, an estimation of the lifespan of the media can be made based on the fluoride concentration of the source water, the volume of water filtered each day and the adsorption capacity of the bone char.

## Acceptance

The use of bones in water treatment might not be consistent with local customs and beliefs. Depending on the community, it may be important to consider the implications of religious beliefs, etc. on acceptance of using bone char for water treatment.



Bone Char Domestic Defluoridator Developed by  
ICOH-Thailand (Credit: Lyengar, 2002)

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## Key Data

### Inlet Water Criteria

- No specific limits

### Treatment Efficiency

	Bacteria	Viruses	Protozoa	Helminths	Turbidity	Fluoride
Laboratory	Not available	N/A	N/A	N/A	N/A	65% in batch <sup>1</sup> 99% in flowing system <sup>2</sup>
Field	N/A	N/A	N/A	N/A	N/A	90% <sup>3</sup>

<sup>1</sup>Watanesk and Watanesk, 2000

<sup>2</sup>Mavura et al., 2002

<sup>3</sup>CDN, 2006

### Operating Criteria

Flow Rate	Batch Volume	Daily Water Supply
Not available	1.6 to 6.5 litres <sup>1</sup>	Not available

<sup>1</sup>Depending on filter type (WHO, 2006)

- The flow rate, batch volume and daily water supply depend on the kind of filter used

### Robustness

- Taps can be broken and may need replacement
- Bone char needs to be replaced or regenerated when saturated
- It is necessary to measure the fluoride concentration in the outlet water to know when to replace or regenerate media

### Estimated Lifespan

- Estimating the lifespan can be made based on the fluoride concentration of the source water, the water volume filtered each day, and the adsorption capacity of the bone char
- According to Catholic Diocese of Nakuru Water Quality's laboratory research, the filter can be filled 200 times with water (using an inlet concentration of 6 mg fluoride/litre) before the fluoride concentration in the outlet water exceeds 1.5 mg fluoride/litre

### Manufacturing Requirements

#### Worldwide Producers:

- Bone char is still produced in several countries as it is used in food industries such as sugar production

#### Local Production:

- Bone char can be produced locally in any country

#### Materials:

- Bones from animals
- Furnace or kiln
- Crushing machine or tools for manual crushing
- Sieves to obtain correct grain size for bone char media

#### Fabrication Facilities:

- Storage place with roof to keep bones dry

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### Labour:

- Anyone can be trained to produce bone char

### Hazards:

- Safety precautions are needed when charring the bones

### Maintenance

- Replacement or regeneration of bone char (skilled labour required)
- Cleaned on a regular basis

### Direct Cost

Capital Cost	Operating Cost	Replacement Cost
US\$17-23 <sup>1</sup>	US\$1.8/1000 litres <sup>2</sup>	US\$1.8/1000 litres <sup>2</sup>

Note: Program, transportation and education costs are not included. Costs will vary depending on location.

<sup>1</sup> CDN, 2006 for the whole defluoridation unit and depending on tap type, Kenya

<sup>2</sup> For bone char media replacement (CDN, 2006)

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