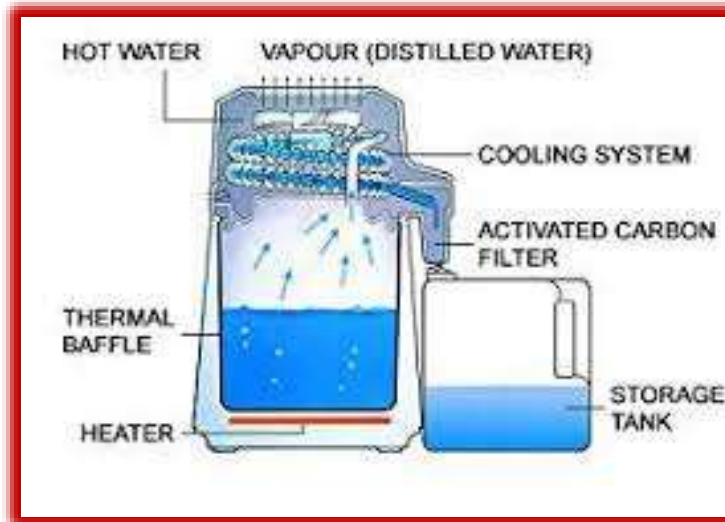


How to select the best water filter for your domestic use ?



PREPARED BY : DR.MRINMOY MAJUMDER,FOUNDING EDITOR(HONR),
INNOVATE FOR SUSTAINABILITY,[HTTP://WWW.BAIPATRA.WS](http://www.baipatra.ws).
FIND ME IN RESEARCHGATE AND LINKED IN AS MRINMOY MAJUMDER
IN TWITTER AND KUDOS AS KUTTU80

Water Filter

How it works ? What filter is useful for what type of contaminants?
How to improve the performance of Water Filters ? How to select
the best water filter most suitable for you ?

Common Impurities and how to remove it from water ?

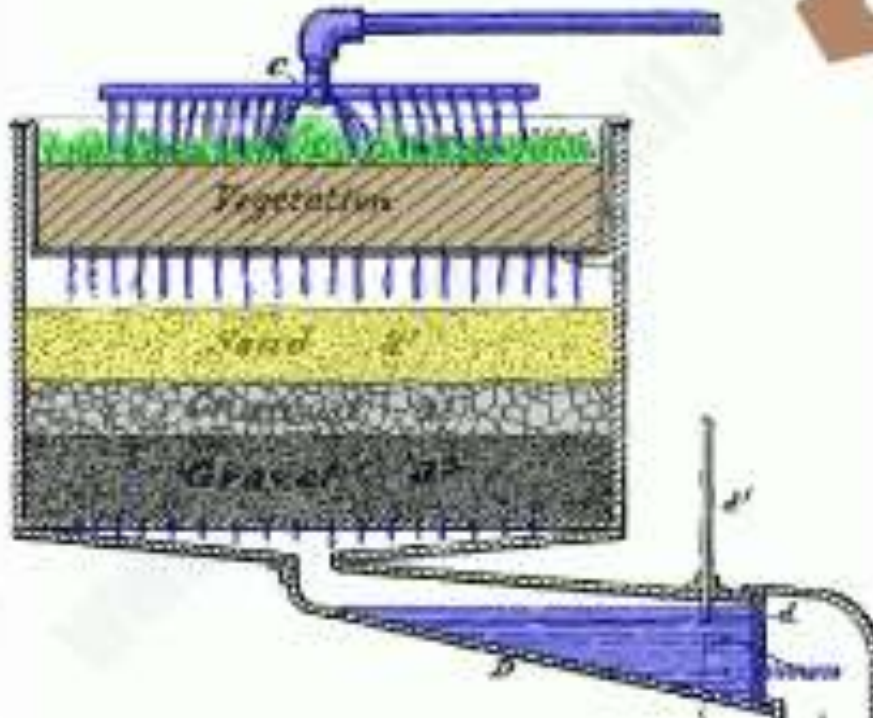


Different Types of Filters

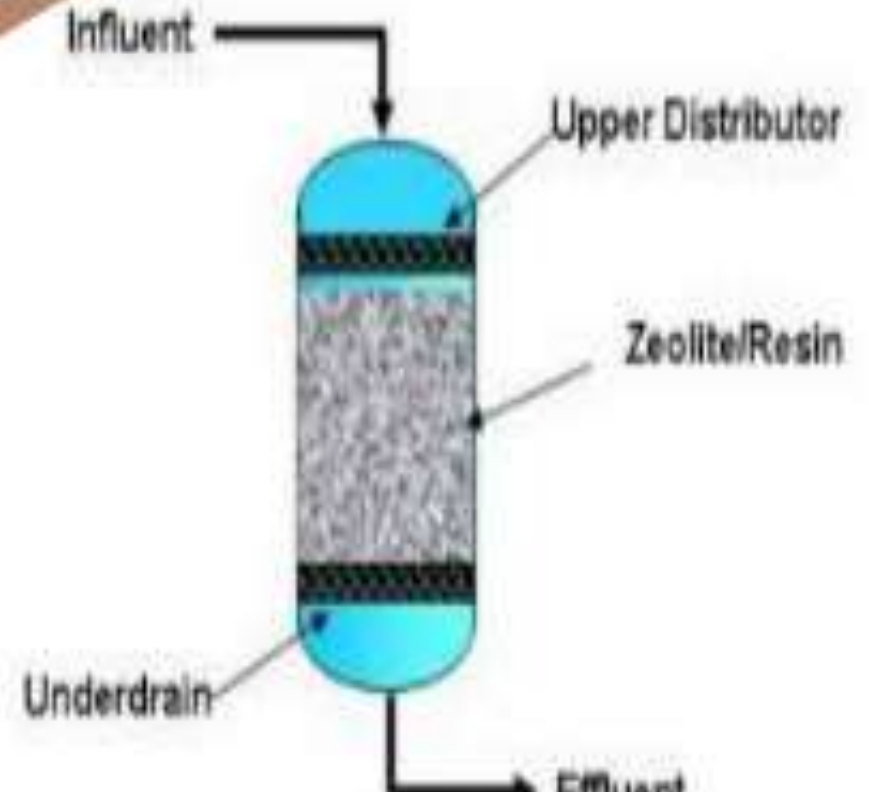
- Broadly filters can be classified into six types :
 - Physical Filters : “filtering by gravity”
 - Ion Exchange : “filtering by exchanging bad ions with good ions”
 - Activated Carbon : “filtering by trapping impurities within pores of carbon material”
 - Reverse Osmosis : “filtering by reversing the process of osmosis thus separating the impurities and water by semipermeable membrane”
 - Distillation : “filtering by boiling”
 - UV Light : “filtering by lights of ultra-violet frequency”
- *A brief description, strength and weakness of the filters are explained in the next slides.*

PHYSICAL
FILTER

U.S. Pat. No. 1,000,000
C. MONJEAU.
PURIFYING WATER.
(Application filed Dec. 10, 1899.)
Patented Sept. 3, 1901.



ION
EXCHANGER



Different Types of Filters

LOW COST
MEDIUM MAINTENANCE

PHYSICAL FILTERS

USE SEDIMENTS OF DIFFERENT
DIAMETERS ARRANGED IN
VERTICAL OR HORIZONTAL
LAYERS

REMOVES IMPURITIES WITH LARGER
DIAMETER COMPARED TO THE
DIAMETERS OF THE SEDIMENTS

USELESS WHEN IMPURITIES ARE OF
SMALLER DIAMETER THAN THE DIAMETER
OF SEDIMENTS
REQUIRES FLUSHING OFF OF IMPURITIES
FROM THE LAYERS OF SEDIMENTS

ION EXCHANGE

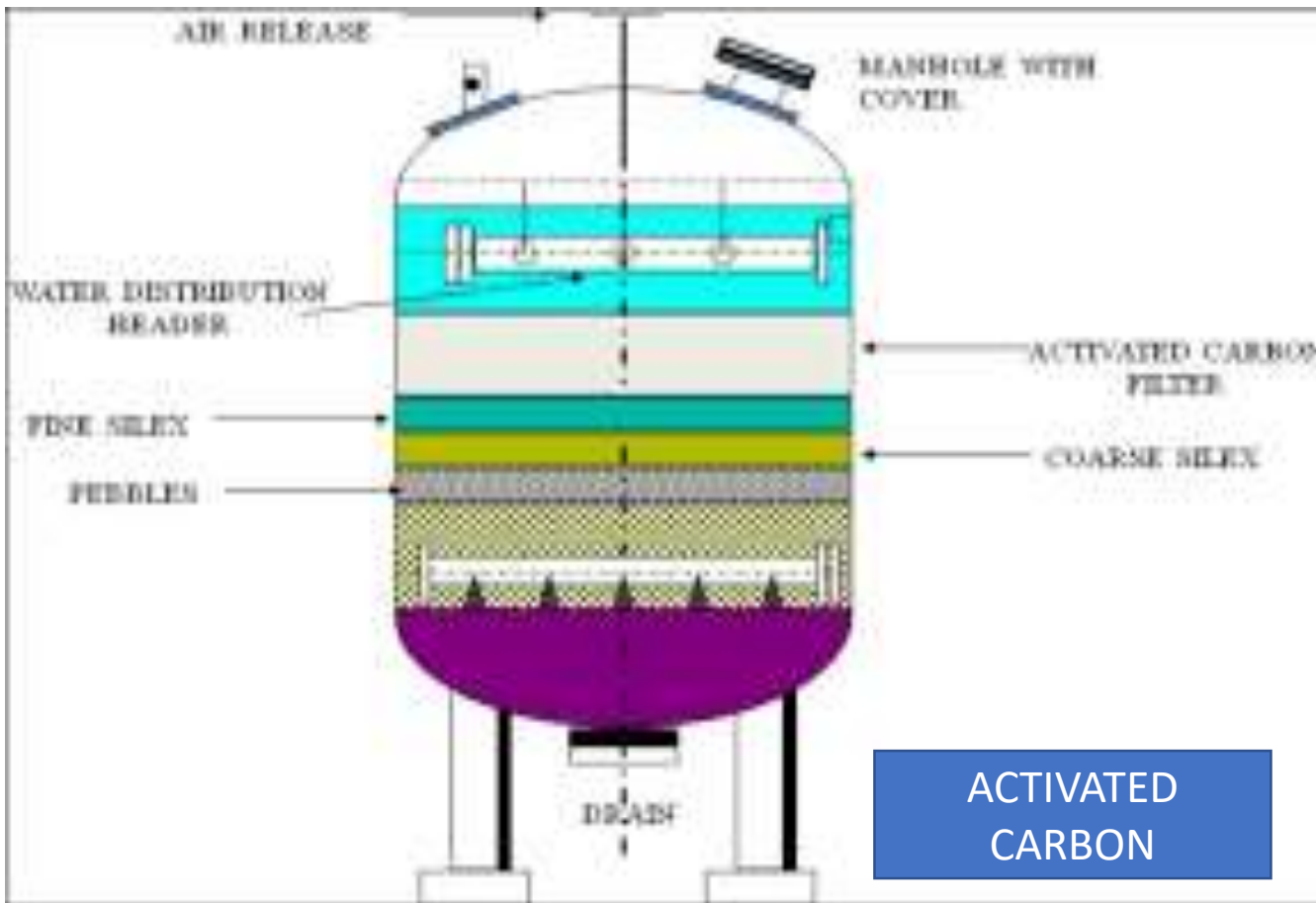
ZEOLITE BEADS CONTAINING SODIUM
IONS ARE USED WHEN HARDNESS
CAUSING IONS LIKE Ca OR Mg
REPLACES THE SODIUM IONS AND GET
TRAPPED WITHIN THE BEADS
THEREBY SOFTENING THE WATER

USEFUL FOR REMOVING HARDNESS
DUE TO CALCIUM AND MAGNESIUM IONS

RELEASES SODIUM IONS IN THE TREATED
WATER AND THEREBY INCREASING SALT
CONTENT IN THE WATER WHICH MAY NOT BE
SUITABLE FOR CONSUMERS WITH SALT
RESTRICTED DIETS

HIGH COST
MEDIUM MAINTENANCE

PHYSICAL FILTERS AND ION EXCHANGE FILTERS



ACTIVATED
CARBON



REVERSE
OSMOSIS

ACTIVATED CARBON AND REVERSE OSMOSIS FILTERS

ACTIVATED CARBON

USES ACTIVATED CARBON GRANULES LIKE CHARCOAL WHICH ARE GENERATED FROM BURNED WOODS OR COCONUT SHELLS. CHARCOALS ARE HIGHLY POROUS AND ADSORBS COMMON IMPURITIES OF WATER

CAN REMOVE MOST OF THE COMMON IMPURITIES INCLUDING CHLORINE, PESTICIDES AND INDUSTRIAL SOLVENTS

CANT REMOVE HARDNESS, HEAVY METALS, MICROBES, SODIUM, NITRATES, FLUORINES

LOW COST
LOW MAINTENANCE

REVERSE OSMOSIS

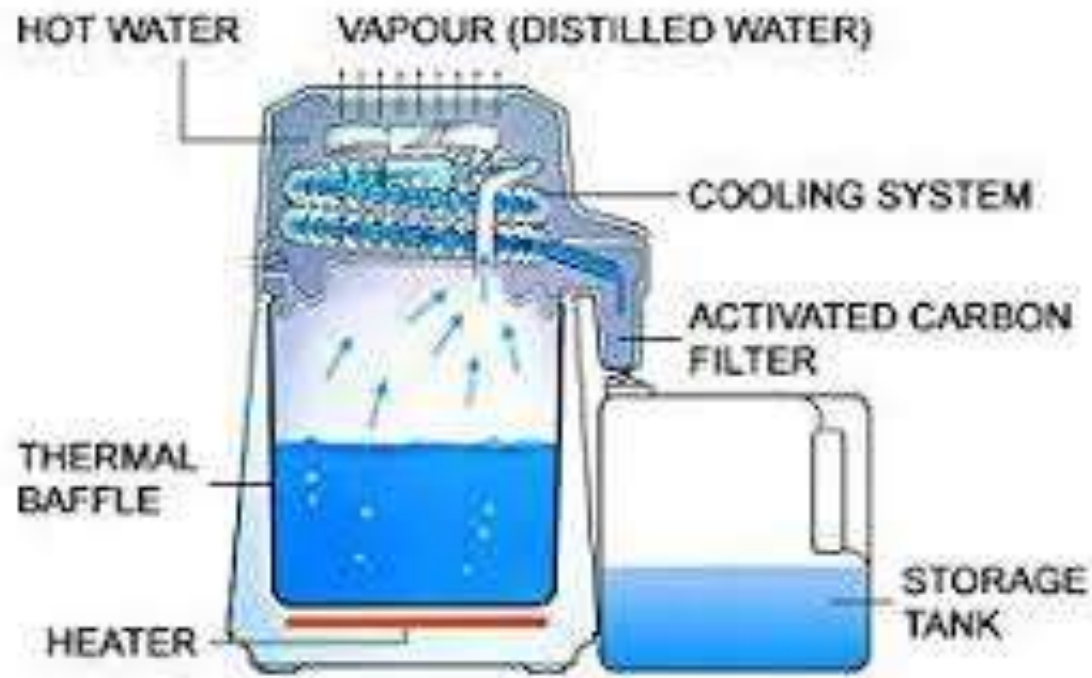
FOLLOWS THE OSMOSIS THEORY OF BIOLOGY. IN OSMOSIS IF TWO LIQUIDS OF DIFFERENT CONCENTRATIONS ARE SEPERATED BY A SEMI PER MEABLE MEMBRANE THEN LIQUID FROM LOW CONCENTRATION WILL MOVE TOWARDS HIGH CONCENTRATION. IN THE REVERSE OSMOSIS OPPOSITE OF OSMOSIS OCCURS DUE TO AN ARTIFICIAL PRESSURE CREATED OVER THE MEMBRANE

AT THE TIME OF REVERSE OSMOSIS THE CONTAMINANTS MIXED IN WATER CAN NOT PASS THE SEMI PER MEABLE MEMBRANE AND IN TURN PURE WATER CAN BE RECEIVED AT THE OTHER END OF THE MEMBRANE

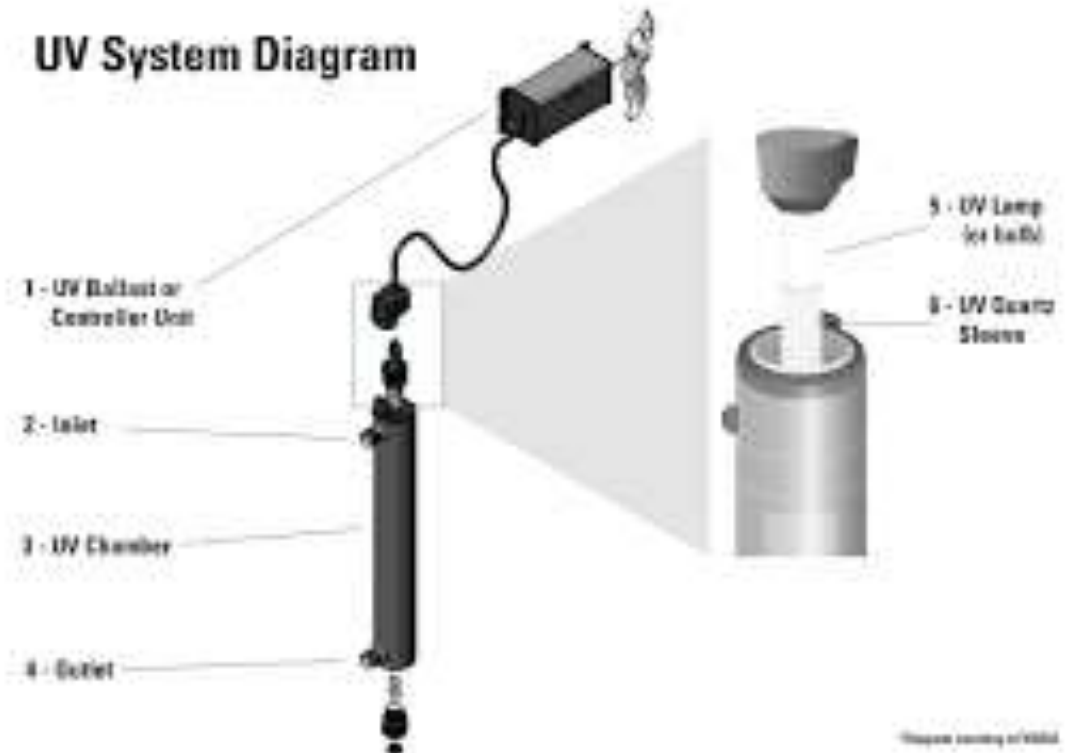
REVERSE OSMOSIS PRODUCE A LOT OF WASTE WATER RELEASE OF WHICH BECOME A PROBLEM FOR THE USER

HIGH COST
HIGH MAINTENANCE

Distillation vs UV Filters



UV System Diagram



DISTILLATION AND UV FILTERS

DISTILLATION

IMPURE WATER IS BOILED AND VAPOURIZED. THE WATER VAPOUR IS THEN CONDENSED BY PASSING IT THROUGH A COOLANT AND THE CONDENSED WATER IS USED AS TREATED WATER

CAN REMOVE MOST OF THE COMMON IMPURITIES AS BOILING POINT OF MOST OF THE CONTAMINANTS ARE HIGHER THAN WATER

BUT SOME VOLATILE ORGANIC COMPOUNDS HAVE LOWER BOILING POINT AND THUS REMAINS IN THE VAPOURIZED WATER. ALSO EXTERNAL ENERGY IS USED TO VAPOURISE WATER WHICH INCREASES THE COST OF TREATMENT.

HIGH COST
MEDIUM MAINTENANCE

UV FILTER

USES ULTRA VIOLET LAMPS ON IMPURE WATER. UV LIGHTS CAN EXTERMINATE MOST OF THE WATER BORNE BACTERIAS

CAN REMOVE OR KILL MICROORGANISMS

AS EXTERNAL ENERGY IS REQUIRED COST OF TREATMENT GET INCREASED, LAMP IS REQUIRED TO BE CHANGED AT REGULAR INTERVALS SO THERE WILL BE A PERIODIC MAINTENANCE COST.

HIGH COST
HIGH MAINTENANCE



How to select the best water
filter by Simple Decision
Maker

**FACTORS TO BE CONSIDERED BEFORE
PROCURING A FILTER**

**IN ORDER OF IMPORTANCE
(MAY BE ADJUSTED BASED ON PERSONAL REQUIREMENTS)**

CRM

CONTAMINANT REMOVAL EFFICIENCY

MAINTENANCE

**COST AND FREQUENCY OF MAINTENANCE
REQUIRED**

COST OF PURCHASE

COST OF PROCUREMENT REQUIRED

TYPE OF FILTERS

**HOW MANY TYPE OF FILTERS INCLUDED
AND HOW MANY TIMES THE SAME FILTER
IS USED**

How to select the best water filter ?

How to select the best water filter ?

- Step 1 : Go to <https://tinyurl.com/y4g2slld>. This is the link to a “Simple Decision Maker by AHP” Webware which will help to select the best filter(to be more precise : filter configurations) with the help of some criteria and following the most famous decision making method : Analytical Hierarchy Process(AHP). For more details about AHP go to :

<https://learnmetaheuristics.blogspot.com/2019/06/simple-decision-making-tool-following.html>

- Step 2 : Select the set of criteria based on which you will identify the best filter among the available options ([Go to Slide No.10](#)).
- Step 3 : For example, let four different types of filter configurations are available for procurement. The table in the [next slide](#) depicts the cost of purchase, type of filter, number of stages, maintenance cost and frequency and contaminant removal efficiency of the available filter configurations.

Name of Filter Configurations*	Cost of procurement (INR)	Type of filter	Number of Stages	Cost of Maintenance (INR/six month)	Frequency of Maintenance(per year)	Contaminant Removal Efficiency (%)
Filter A	2500	Activated Carbon	2	100	3	55
Filter B	3500	Activated Carbon + UV Light	2	125	2	65
Filter C	7500	Activated Carbon + Ion Exchange + UV Light	4	250	2	75
Filter D	15000	Activated Carbon + Reverse Osmosis + UV Light	5	500	1	85

*Number of different types of filters are arranged to create one filter configuration which is sold to consumers. Normally a filter configuration have more than one stage(Stage means one type of filter). In this example only those configurations which have minimum 2 stages are considered. Same type of filter can also be used in more than one stage.

Note : This example is for demonstration purpose only.

Name of Filter Configurations*	Cost of procurement (INR) /Rank	Number of Stages /Rank		Cost of Maintenance /Rank		Contaminant Removal Efficiency (%) /Rank
Filter A	2500/ 01	Activated Carbon	2 / 03	100	3 / 02	55 / 04
Filter B	3500 / 02	Activated Carbon + UV Light	2 / 03	125	2 / 01	65 / 03
Filter C	7500 / 03	Activated Carbon + Ion Exchange + UV Light	4 / 02	250	2 / 03	75 / 02
Filter D	15000 / 04	Activated Carbon + Reverse Osmosis + UV Light	5 / 01	500	1 / 03	85 / 01

Now try to rank the filter configurations based on its characteristics represented by the selected criteria. It is better to represent Type of filter and number of stages by a single criteria :Number of Stages(as it depend on both type and number of stages) and Cost and frequency of maintenance as : Cost of Maintenance(cost will depend on cost per maintenance as well as number of times maintenance is required per year).

How the filter configurations were ranked ?

- For Cost of Procurement and Cost of Maintenance, more the cost less will be preference to buy as all the consumers tries to look for cheaper alternatives having low cost and requirement of maintenance. That is why while ranking the filter configuration with respect to the cost of procurement and maintenance more the cost of the configuration less rank was awarded. The configurations were sorted in such a manner that the costliest configuration received the worst rank or preference.
- For Number of Stages criteria, as more the number of stages more contaminant can be removed. That is why more the number of stages higher rank of preference was awarded to the configuration
- For Contaminant Removal Efficiency, more the removal efficiency of the configuration more preference will be given and thus highest rank of preference was awarded to the configuration which have maximum contaminant removal efficiency.

How to find the best filter configuration by Simple Decision Maker Webware ?

- When the link is opened the Home page will delineate the procedure to be followed. First of all convert the ranks to “Complement of Normalized Rank” by following the instruction in the home page of the software.
- For the present example, we have four alternatives. So rank assigned to the alternatives will be converted to its normalized rank by :

$$\frac{x}{4 + 1}$$

where x is the rank assigned to the alternative.

and Complement of Normalized Rank will be calculated by :

$$\left\{1 - \frac{x}{4+1}\right\}$$

Complement to Normalized Rank

Name of Filter Configurations*	Cost of procurement (INR) /Rank	Number of Stages /Rank		Cost of Maintenance /Rank		Contaminant Removal Efficiency (%) /Rank
Filter A	0.8	Activated Carbon	0.4	100	0.6	0.2
Filter B	0.6	Activated Carbon + UV Light	0.4	125	0.8	0.4
Filter C	0.4	Activated Carbon + Ion Exchange + UV Light	0.6	250	0.4	0.6
Filter D	0.2	Activated Carbon + Reverse Osmosis + UV Light	0.8	500	0.4	0.8

Assigning Rank of Preference to the Criteria

- Now a Complement to Normalized Rank of Preference to the Criteria is required to be assigned.
- For this example : Contaminant Removal Efficiency(CRE) will be the most important criteria followed by Cost of Maintenance(M), Cost of Procurement(P) and lastly the Number of Stages(S)([See Slide 10](#)).
- Accordingly the Complement to Normalized Rank of Preference was calculated and found to be equal to
- $CRE : 0.8 > M : 0.6 > P : 0.4 > S : 0.2$.
- After these values were entered in the place of Criteria go to AHP page to find the results.
- For this example Filter A becomes the best filter due to very low cost of maintenance and procurement. Filter D, although it has the best CRE but due to high cost of procurement and maintenance it become the least preferred alternative.

	ASSIGN RANK OF IMPORTANCE wrt	CRITERIA[1]						ASSIGN RANK OF IMPORTANCE wrt	GOAL [2]
CODE	NAME OF OPTIONS/ALTERNATIVES/SOLUTIONS	C1	C2	C3	C4	C5	CODE	NAME OF CRITERIA	
A1	Filter A	0.8	0.4	0.6	0.2		C1	Cost of Procurement	0.8
A2	Filter B	0.6	0.4	0.8	0.4		C2	Number of Stages	0.6
A3	Filter C	0.4	0.6	0.4	0.6		C3	Cost of Maintenance	0.4
A4	Filter D	0.2	0.8	0.4	0.8		C4	Contaminant Removal Efficiency	0.2
A5							C5		
A6									
A7									
A8									
A9									
A10									

PLACE OF ALTERNATIVE

PLACE OF CRITERIA

Assign Rank Window in Simple Decision Maker

RESULT FROM AHP		
	OPTIONS/ALTERNATIVES/SOLUTIONS	RANK OF DOMINANCE [1]
A1	Filter A	1
A2	Filter B	2
A3	Filter C	4
A4	Filter D	3
A5		
A6		
A7		
A8		
A9		
A10		

PLACE OF RESULT

Update

Reset

Print All

Submit

Real-time Sync

0

AHP window of Simple Decision Maker Webware

Thank you

- Visit me in **Innovate for Sustainability**(<http://www.baipatra.ws>)
- Join the group :
Water, Energy and Informatics
(<http://groupspaces.com/WaterResourceManagers/>)