ACTIVATED CARBON

This Greenpaper discusses Granular Activated Carbon (GAC) and its application

1:00 KEYWORDS

WATER	FILTRATION
WATER TREATMENT	PARTICLES
IMPURITIES	COLLOIDS
IONS	ASH
IODINE NUMBER	DECHLORINATION

2:00 INTRODUCTION

Granular Activated Carbon (GAC) adsorption is a reliable and effective method of removing most organic impurities found in potable water as well as dechlorination.

In use since the nineteenth century it has become established as an effective process for dechlorination, detergent[1], insectiside[2], virus[3], specific chemical pollutants[4], taste and odour[5]. This experience establishes that carbon bed filtration removes a high percentage of undesirable contaminants from water with efficiency over a wide range of impurity and applications.

This Greenpaper discusses the use of GAC **in potable water treatment.**

3:00 GRANULAR ACTIVATED CARBON

Fig #1 GAC Raw Material

This is produced from coconut shells, wood, coal or other carbonaceous sources (Fig #1).

Raw material is fed from a hopper into a rotary kiln in a continuous steam driven carbonisation process with a temperature range 900~ 1100°C. Further reaction of the charcoal formed with the high temperature steam causes expansion of the granule forming internal spores so greatly increasing the active surface area of the granule.

Fig #2 Example GAC

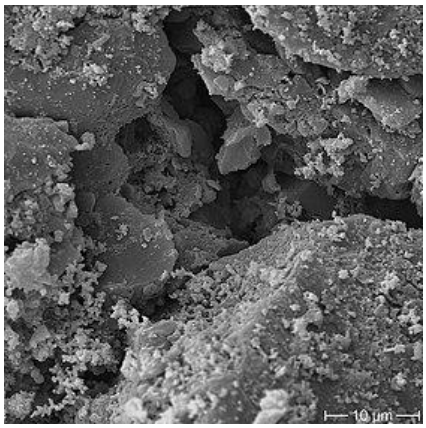

Fig #3 Structure GAC

Industry evaluation in long term operation has established a clear advantage in the use of granular activated carbon over powdered carbon in terms of adsorption efficiency as further evidenced by the work of Joyce[6].

A gram of activated carbon has a surface area in the range of 500 ~ 3,000 m^2. Electron microscope scan (Fig #3) reveals the high surface area with individual particles convoluted with varying porosity but "flat" areas of graphite are also visible. This structure provides micropores providing ideal conditions for adsorption with simultaneous interaction at many surfaces.

Activated Carbon adsorbs iodine very efficiently providing a convenient measure of performance.

An important criteria in activated carbon selection is ash content. This reduces the overall capacity of activated carbon also reduces reactivation efficiency. Activated carbon with a low soluble ash content should be used for potable water marine, and freshwater fish farming primarily to reduce heavy metals and potential algae growth. Acid / water soluble ash content is the preferred criteria against total ash content thus "acid washed" activated carbon should be used for these applications.

BASE MATERIAL	ASH
Coconut	2 ~ 4%
Wood	3 ~ 6%
Coal	5 ~ 15%
Lignite	25 ~ 30%

4:00 ADSORPTION - FILTRATION

A study by Rebeck et al[7] investigating the removal efficiency of activated carbon when challenged by poliovirus in potable water established the superiority of carbon than sand beds. Even when exhausted carbon still maintained a higher performance than sand.

This and similar work established that abrasion resistant granular activated carbon can serve as both filtration and adsorption media.

The results of Smith and Skeel[8] are summarised as:

60 days
Odour Threshold 70 reduced to 4
Turbidity maintained <0.07 Jackson Units

Free Chlorine 2.8mg/l reduced to <0.25mg/l

Post 60 days (Odour removal capacity exhausted)
Colour, iron, manganese, chlorine and turbidity exceeded sand

5:00 DECHLORINATION

Dechlorination by GAC is extremely reliable and very effective. GAC acts principally as a catalyst in the reduction of hypochlorous acid to the chloride ion thus the capacity of carbon is determined by other parameters than adsorption:

$$2Cl_2 + C + 2H_2O \longleftrightarrow 4HCl + CO_2$$

or

$$Cl_2 + H2O \longleftrightarrow 2H^+ + 2Cl^- + O$$

chemisorbed nascent oxygen decomposes in one of two ways:

$$C_xO_x \longrightarrow C + CO$$

Or

$$C_xO_x \longrightarrow C + CO_2$$

Particular study of the carbon – chlorine system to define a relationship between flow, bed depth, concentration of influent and effluent chlorine together with granular carbon its self was studied by Magee[9]. Further work was carried out by Fairm, Geyburn and Oukum[10] and others to establish the dechlorination service life of GAC using rapid gravity type filters with typical flow rates of 2.5 usgpm, 280 ft^2 filter surface, 2.5ft filter bed depth, 700ft^3 GAC media and chlorine influent of 4ppm. With an initial chlorine breakpoint of 0.01ppm free chlorine end of cycle was almost two years. Repeating this work but at 2ppm chlorine influent extended service time to almost six years.

Thus, dechlorination capacity far exceeds that of nuisance capacity.

OPERATING CRITERIA – PRESSURE FILTERS

Filtration Rate	2 ~ 8 $m^3/hr/m^2$ (Flux)
Filtration Area	0.2 ~ 7m^2
Contact Time	10 ~ 30 minutes
Vessel Diameter	0.5 ~ 3m
Flow Rate	10 l/h ~ 100m^3/h
Pressure	3 ~ 4 barg

6:00 IODINE NUMBER

As many carbons preferentially adsorb small molecules a universal standard of measurement is required. This is known as the **Iodine Number**. This is a measure of the activity level of the activated carbon with a higher number equating to higher activity generally reported in the range 500 ~ 1200 mg/g (in practice the Iodine Number is usually quoted unit less). This value is a measure of the micropore capacity 0 ~ 20 A^o (approx 2 nm) of activated carbon to adsorb iodine from solution. This is the standard method for liquid-phase applications approximately equal to a carbon surface are 900 ~ 1100 m^2/g.

In water treatment applications activated carbons have an iodine number ranging from 600 ~ 1100. In service this value is monitored

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Any comments, insights or further information on this Greenpaper please advise terry@portablewell.com. I look forward to hearing from you.

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Since entering the industry the author has now accumulated 50 years of experience in design, engineering, execution and troubleshooting water and wastewater systems with experience in building services, power both fossil and nuclear, potable and municipal water and wastewater systems including desalination and tertiary, pharmaceutical, microelectronics, petro-chemical and general industry. He is the author of many published works including Greenpapers of which this document is one. While primary contact is via UK involvement is and has been worldwide with ongoing international activities.