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IMPLEMENTATION OF GRANULAR ACTIVATED CARBON IN THE DRINKING WATER TREATMENT PLANTS IN ROMANIA

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Abstract. Increasing environmental awareness and concern are certain to emphasize and expand the role of activated carbon in water and wastewater treatment technology. Although adsorption on carbon is even now a highly effective process for removal of most organic compounds from aqueous solutions, continuing improvement in carbon selection, in carbon preparation, and in process design and operational performance is likely to be achieved as clearer delineation of the fundamental issues involved in the process is attained. The effective interfacing of a better understanding of the fundamental concepts underlying adsorption dynamics with practical applications will constitute a continuing challenge to those involved in this field. The present paper deals with experimental pilot plant results obtained on granular activated carbon (GAC) type Chemviron and natural surface water from Hasdate river. The obtained data were applied for implementation in the drinking water treatment plant of Campia Turzii, Romania.

Keywords: adsorption, active carbon, treatment plant, drinking water.

AIMS AND BACKGROUND

Development of industrial societies has lead to proliferation of a vast number and variety of complex chemicals for industrial agricultural and domestic use. Many of these compounds exhibit toxic, carcinogenic, mutagenic or teratogenic properties and may have insidious effects on man and his environment in uncontrolled exposure situation.

Many compounds of such concern eventually find their way into municipal and industrial wastewaters and, unless specifically removed by waste treatment process, ultimately appear in receiving waters and water supplies; in reality the distinction between water and wastewater has been bridged, spatially and temporally.

Awareness of the presence and formation, by chlorination, of trihalomethanes and other chlorinated hydrocarbons compounds in drinking water has also increased.

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In this respect, activated carbon adsorption has evolved as the most effective and dependable technology for thc removal of a broad spectrum of dissolved organic impurities found in waters and waste waters. It is obviously that activated carbon will become a dominant factor in water and wastewater treatment. Pertinent avenues of potentially rewarding search include: integrated biological adsorption processes which utilize expanded beds of granular activated carbon with a fixed film biological growth on the adsorbent surface; combined application of ozonation and adsorption; removal of chlorinated hydrocarbons and/or their formation precursors; and development of predictive mathematical models capable of functioning as more rigorous bases for system design and operation.

Literature[1-3] reports well-defined sequence of stages of drinking water treatment process capable of ensuring the essential conditions needed for adsorption on activated carbon. Figure 1 shows a flow scheme describing the optimum process, including the necessary disinfection considerations.

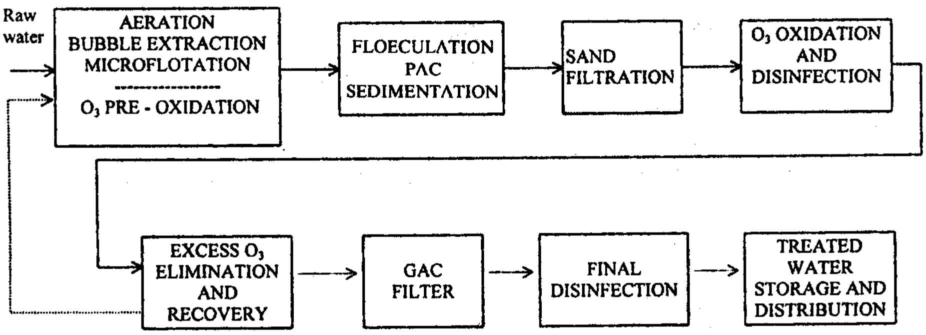

Fig. 1. Stages in drinking water treatment process

Although fundamental investigations have generally demonstrated process effectiveness and limitations in the above and related areas, empirical research is required for further delineation of the underlying principles.

The specific character of adsorption on carbon is considered from the standpoints of quantum mechanics, thermodynamics and mass transport processes. Methods are presented for quantifying adsorption equilibria and dynamics, and for process modelling and simulation.

EXPERIMENTAL

Characterization of activated carbon. Classical methods based on the physical adsorption of inert gases are used as techniques to discover information concerning surface area and porosity. However, the information is too general to be applied to activated carbon. Activated carbon adsorption of solutes from solution can give more relevant information. For instance, the dimensions of the pores may be obtained from the study of adsorption with solutes of increasing molecular mass. The form of the adsorbed molecules may give information concerning the type of the pores. Moreover, such kind of method could be used to assist the selection of the adsorbent, and it is consisting in the study of the equilibrium conditions of adsorption isotherm. While this method seems satisfactory for the characterization of powdered activated carbon (PAC) and it is adaptable for all types of activated carbon intended for use in adsorption process at equilibrium, another method should be used for the characterization of granular activated carbon (GAC) used in dynamic system with column.

For the study of the adsorption isotherm should be followed a special procedure, shortly described in the next steps:

- The activated carbon (AC) of interest should be brought to uniform pure particle size by grinding, sieving, then washing and drying – all operations beeing done in a typical/specific manner.
- Contacting a measured quantity of PAC with a measured volume with known concentration of solute, at a constant temperature and for an enough large period of time to reach the adsorption equilibrium. At last 8 points of coordinates (x,y) where x and y are the solute concentration at equilibrium, in liquid, respectively on solid phase, are necessary for each adsorption isotherm. Repeating the same procedure (of batch adsorption) for known different solutes, eventually belonging to the same class of organic compounds, but having different molecular mass.
- Representing and modelling the data (x,y) in the Dubinin – Radushkevitch isotherm coordinates[4-6] could be obtained the following information for the adsorbent used:

  – the total volume of micropores W_{mi} (cm^3/g);

  – the internal surface (micropores) S_{mi} (m^2/g) and the external one S_e (m^2/g) of the adsorbent;

  – the width L (nm) of micropores and even the thickness t (nm) of the adsorbed layer of solute on the non-microporous surface.

Another second method, which is dynamic, requires adsorption column. In this case the similarity of the mechanism in the laboratory and full-scale application makes it possible to obtain experimentally valuable information regarding the GAC bed.

Usually the studies carried out in a pilot plant require a long period for experimentation. By introducing special measures it is possible to obtain useful information in less time with a laboratory apparatus. Figure 2 shows a schematic representation of the apparatus used.

A corroborating study undertaken in our laboratories concerns the comparison between adsorbent power of Chemviron versus the treatment with ozonated

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water. The study was conducted in respect to specific organic charges that were found in the Hasdate river, the main supply of water for the city of Campia Turzii.

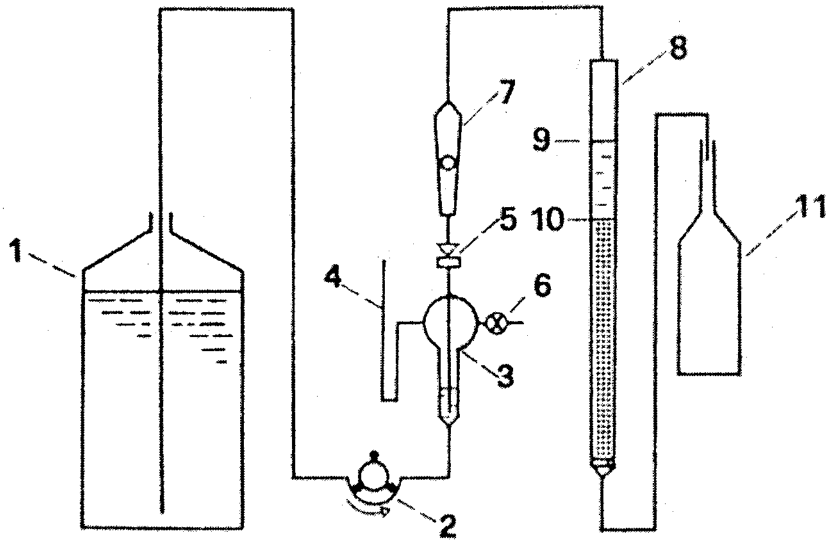

Fig. 2. Apparatus for adsorption studies on GAC in dynamic conditions
1 – aqueous solution container, 2 – peristaltic pump, 3 – expansion bulb for solution flow uniformity, 4 – water pressure manometer, 5 – microvalve, 6 – outlet valve, 7 – rotameter, 8 – adsorption column, 9 – solution level, 10 – GAC level, 11 – sample collection container

Preliminary experiments concerning the quality of Hasdate river. The studies of the quality of Hasdate river have been started in ICIM in 1991, when by a research program – that followed the prognosis and the treatability in the case in which an artificial lake has been supposed to be formed on the Hasdate river.

In 1993, following another research program, it was started the study focussed on the optimum technology for treatment of the Hasdate river. In this respect, at the beginning of the study, there have been done three sampling campaigns (spring, summer and autumn) during the 1993 year. There were analyzed 35 physico-chemical and biological indicators.

The quality indicators reveal that even the river quality was acceptable referring to some indicators (the COD indicates the water of Hasdate river to be almost first class of quality), for some other indicators (as biological, respectively the fitoplanctonic biomass) the content in organic substances was quite appreciable. This observation was strictly associated with the existence of some fishing ponds upstream the catchment section. For this reason, the classical scheme of water treatment is not suitable, and some treatability experiments, simulating the mixing-coagulation, decantation, filtration (GAC) or oxidation (ozone), and disinfection (ClO_2) steps have been analyzed.

An optimum theoretical scheme for the Hasdate river treatment plant was established:

- coagulation (with 20-30 mg/l $Al_2(SO_4)_3$);
- oxidation (with $KMnO_4$) and CAP treatment;
- treatment with flocculants in cold seasons (lime and active silica);
- decantation (≅1 h);
- sand filtration (6-7 m/h);
- GAC filtration (15-20 min) and
- chlorination (1-1.5 mg Cl_2/l).

RESULTS

Pilot plant results obtained after laboratory studies aimed to compare the efficiency of three filtration systems: GAC, sand, and combined GAC and sand. The measurements carried out between October 31, 1998 and May 30, 1999 revealed the optimum efficiency for GAC filtration, as it can be seen in Fig. 3.

Based on this laboratory and pilot plant data a new filtration step with GAC was implemented into the treatment plant at Campia Turzii treatment station, thus beeing obtained a good quality of drinking water of this city.

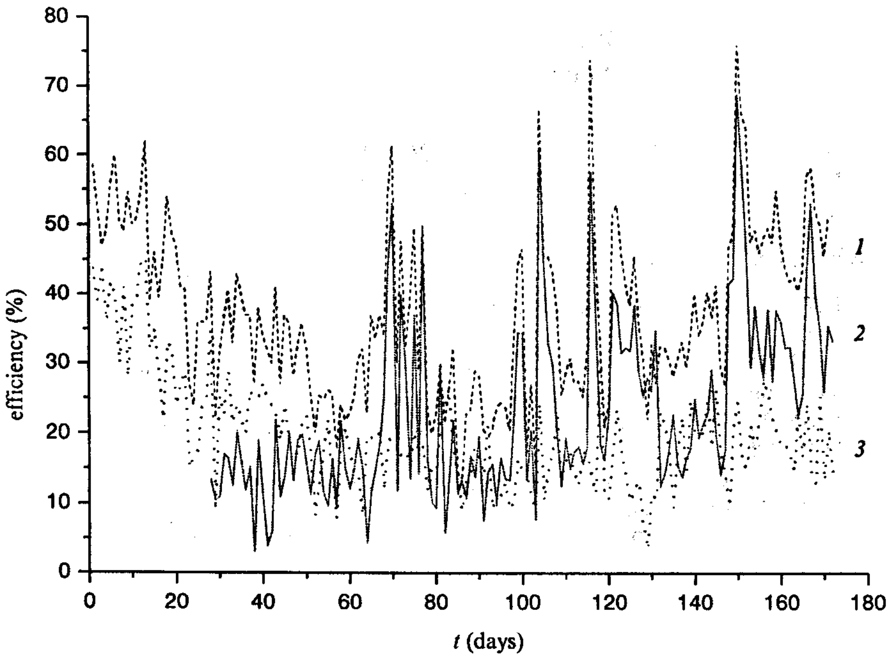

Fig. 3. Efficiency in time of different filtration systems
1 – GAC, *2* – sand, *3* – combined GAC + sand

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CONCLUSIONS

• Particular structure characteristics of graphitic carbon make it an adsorbent having a wide applicability in the treatment of drinking water. In order to reach the optimum utilization of this adsorbent, the laws governing adsorption on porous solids appear to hold. The mechanism by which the adsorption process occurs results in the effective treatment of large volumes of water containing small concentrations of organic matter.

• Even if the combination of the process of flocculation with GAC presents difficulties, it can assure reduction of at least 70% of the organic materials present in the water. Therefore, the water arriving at fourth stage, which contains only 25% of the organic load entering, finds itself in optimum conditions for oxidation and complete disinfection. Proper monitoring at first stage and the controlled addition of PAC removes a practically constant load of organic materials, even in the case of sudden variations at the input.

• The combined use of several stages of absorption assures the most complete flexibility and reliability of the drinking water treatment plant from a public health viewpoint. Final disinfection with ClO_2 does not cause any problems because the almost complete elimination of the organic materials prior to this disinfection stage allows the addition of very small quantities of the disinfectant compound.

• On a physico-chemical basis, the most promising technique for obtaining maximum efficiency, flexibility and reliability in the removal of organic matter is the combined use of adsorption at the air-water interface together with PAC followed by GAC.

• Proper utilisation of activated carbon is closely related to the proper succesion of the various stages of water purification.

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