SSP PhD Topic

MEMBRANE-COAGULATION REACTOR FOR WATER TREATMENT

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DURATION: 4 years

INTRODUCTION:

Figure 1 is a process diagram for a conventional water treatment plant. The combination of the first 3 steps primarily removes colloids (including some microorganisms) and natural organic matter (NOM). Step 4 (rapid sand filtration) is a polishing step that removes much of the colloidal material remaining after step 3 (sedimentation)

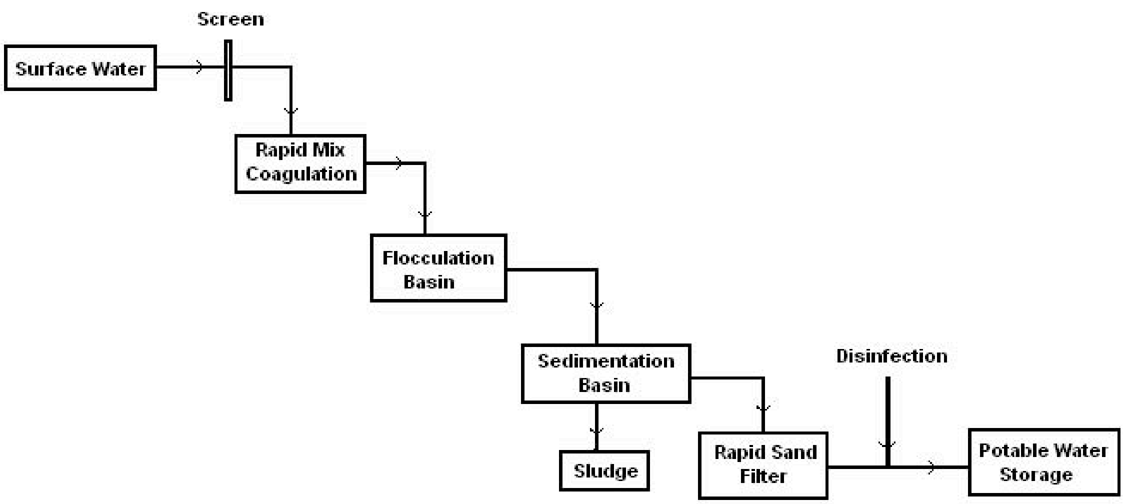

Figure 1 Flow diagram of a conventional potable water treatment plant.

Systems of the type outlined in Figure 1 can provide good quality, potable water and their design and operation are well understood. In recent years membrane alternatives[1,2] have drawn increasing interest because membrane technologies have advanced significantly and membrane systems may:

1. Require considerably less space to treat a given flow
2. Reduce chemical requirements
3. Produce a water that is more easily disinfected and less likely to produce undesirable disinfection by-products

We propose to study a membrane-coagulation reactor (MCR) system (Figure 2). The MCR incorporates flocculation, sedimentation and filtration in 1 reactor instead of 3, suggesting the potential for substantial savings in space and capital costs. The potential water quality benefits arise because the membranes may block a substantial fraction of the small colloids, low molecular weight NOM, and microorganisms that do not sediment and pass through conventional sand filters. Reduction in chemical usage is less certain but may result because of the MCR system's ability to retain even small flocs.

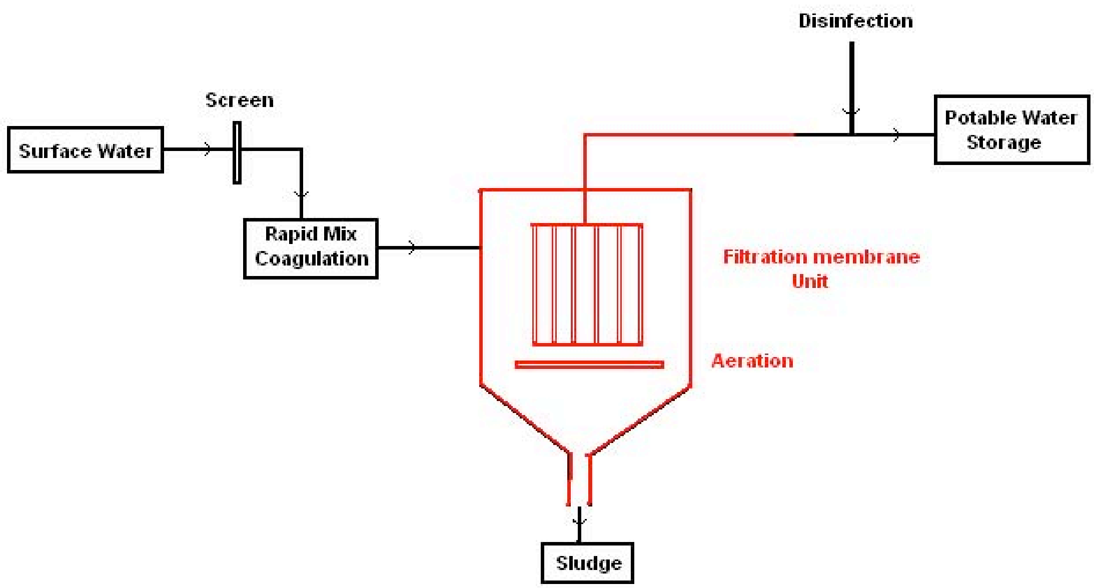

Figure 2 Flow diagram of membrane-coagulation reactor.

Though the potential advantages of an MCR are apparent there are a number of important issues to address.

Membrane fouling is an obvious concern. Both the magnitude of fouling and its effects on flux and permeate quality are likely to depend, in complex ways on membrane properties and configuration, raw water quality, coagulant dose, additives employed, operating parameters of the rapid mix basin, hydraulic residence time, and hydrodynamic conditions in the reactor[3-7].

Conditions in the membrane-coagulation reactor will differ substantially from those in conventional flocculation and sedimentation basins. MCR floc properties—size distribution, morphology, composition, mass and number concentration, etc. may differ substantially from those in conventional systems. Relationships relating flow rates, coagulant and additive dose, etc. that have been elucidated over the years to optimize operation of conventional systems may be inappropriate for MCR systems. Aeration is of particular interest as it is likely to influence hydraulic conditions in the reactor and in so doing inhibit membrane fouling[5,7] and affect floc properties and their settling.

OBJECTIVES

The work will focus on developing both qualitative and quantitative understandings of the properties of a water treatment MCR and of the factors that influence its performance. In particular we will focus on

1. Optimization of reactor operation and configuration
2. Membrane fouling and its control
3. Floc properties--how they can be manipulated, and their relationship to fouling and treatment efficiency
4. Aeration—impacts on fouling, floc properties and treatment efficiency
5. Mass transfer

RESEARCH APPROACH AND RESEARCH TASKS

One or more bench scale MCRs (Figure 2) will be constructed at NTU. The reactor(s) will be computer controlled and equipped with in-line monitoring capabilities (mass flow rate, pH, temperature, pressure, aeration rate, etc.) The student will employ both synthetic and natural waters in parametric studies designed to elucidate the factors that influence treatment efficiency and operational performance. Operational parameters of interest will include:

1. Coagulant dose, chemical additive type and dose, rapid mixing conditions
2. Hydraulic retention time
3. Membrane type, properties
4. Membrane flux, trans-membrane pressure
5. Aeration
6. Reactor configuration

Water quality parameters to be considered:

1. Colloids—turbidity; mineral, microbial, polymeric
2. Organic carbon—TOC, molecular weight distribution; humic, fulvic, coagulant additives
3. Bacteria and viruses
4. pH, temperature, major ions
5. Floc concentration, size distribution, composition, structure

Standard methods will be employed to assess most of the water quality parameters. A range of microscopies (light, SEM, TEM, AFM), and other techniques (electrokinetics, streaming potential TGA-FTIR) will be employed to characterize flocs and evaluate membranes, both virgin and used.

ORGANIZATION AND TRAINING

Professor Sun has an ongoing, complementary research effort focusing on a membrane bioreactor system very similar to the proposed MCR (Figure 2); the student will be a part of Professor Sun's research group. Research will also be synchronised with membrane projects being conducted at Stanford as part of the Clean Water Programme and the NSF Center for

Advanced Materials for Water Purification. When at Stanford, the student will work closely with the researchers involved in these efforts.

REFERENCES

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