

MICROBIOLOGICAL EFFECTS AND CONTROL IN COOLING WATER SYSTEM OF MEDICAL CITY HOSPITAL⁺

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Abstract

This research included the effect of biological fouling on the efficiency of open recirculating cooling water system in medical city hospital of Baghdad . It showed the relation between fouling deposit and conductive heat transfer resistance .

The fouling deposits causes serious problems such as scales and corrosion , ((Utilizing Vials)) method used to determine the quantity of microbiological growth . Sodium hypochlorite (Naocl) used as chemical treatment to control biological fouling growth in this system . It is found that 0.1- 0.2 PPM is the optimum concentration used to control bacterial growth at pH rang 6.5-7.5.

Other sources of chlorine is calcium hypochlorite Ca(Ocl)_2

المستخلص

يتضمن البحث دراسة تأثير الترسبات الحيوية التي تسببها الإحياء المهجيرية مثل البكتيريا بنوعها الهوائية واللاهوائية والطحالب على كفاءة منظومة التبريد المفتوحة في مستشفى مدينة الطب في بغداد . بينت الدراسة العلاقة بين مقدار الترسب الحيوي ومقاومة التوصيل الحراري لأجهزة التبريد .

إن منظومة التبريد مسؤولة عن عملية التبريد في المجمع بأكمله وإن الإحياء المهجيرية ينشط نموها في العراق في فصل الصيف خاصة بسبب توفر المناخ الملائم لنموها (الحرارة والرطوبة) ، وإن وجودها وتركها بدون معالجة تؤدي إلى مشاكل كبيرة تعرض أجهزة التبريد (Chillers) للتلف ، من هذه المشاكل مشكلة التكتلات (Scales) والتآكل (Corrosion) مما يؤدي إلى فقدان كفاءة التبريد وزيادة الكلفة الاقتصادية ، تضمن البحث استخدام طريقة حديثة لحساب كمية النمو البكتيري وهي طريقة (Utilizing Vials) . يتضمن البحث طريقة للسيطرة على هذه الترسبات باستخدام أسلوب المعالجة الكيماوية حيث اقترحت الدراسة استخدام مادة هيبوكلورايت الصوديوم (Naocl المعروف محليا باسم المسحوق القاصر ، هذه المادة مسؤولة عن إنتاج الكلور الحر الكفيل بقتل هذه الإحياء وإيقاف نموها . تم اقتراح هذه المادة كبديل عن المركبات الكيماوية المستوردة من الخارج والتي تكون عالية الكلفة وخلصت الدراسة إلى أن مادة Naocl بتركيز 0.1 - 0.2 جزء من المليون هو أفضل تركيز يمكن استخدامه للسيطرة على نمو هذه الأحياء وعند دالة حامضية تقع ضمن 6.5 - 7.5 مما يؤدي إلى تحسن كفاءة التبريد . وأود الإشارة إلى أن هذه المادة مصدرها من الأسواق المحلية ومتوفرة في مكاتب بيع المواد الكيماوية . ومن المواد الأخرى المرادفة لهذه المادة هي هيبوكلورايت الكالسيوم Ca(Ocl)_2

Introduction

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Excessive growth of microbiological plant life such as algae and bacteria are one of the major fouling deposits , particularly open recirculating cooling water which is excellent growth sites [1].

Biofouling referred to the presence and growth of living organic matter .It can interfere with the water flow through heat exchangers and growth of living organic matter . It can interfere with the water flow through heat exchangers and other conduits

This inhibits heat transfer and contributes to corrosion and general deterioration of the entire cooling system .

Recirculating cooling water systems are ideal incubators for promoting the growth of microorganisms .

Waters saturated with oxygen exposed to sun light maintained at a temperature of 30 to 60 C and having a PH of 6 to 9 ensure abundant nutrients and appropriate environment for life – sustaining growth .

The biofilm can cause losses in heat transfer because of its insulating properties . Three major classes of microorganisms are associated with recirculating cooling water system , algae , fungi and bacteria [2] .

Algae ;Can range from very simple single – cell plants to multi cellular species .

It contain colored pigments (chlorophyll) Algae usually flourish on wetted surfaces such as cooling tower lumber mist eliminator , screens and distribution trays which are exposed to oxygen and sun light .The large slimes of Algae contributes to crevice corrosion and pitting .

Fungi:are similar to algae but don't contain chlorophyll the major fungi of interest is yeast .

Bacteria :are unicellular microscopic plant like organisms similar to algae but lack chlorophyll

The slimes of bacteria can significantly reduce heat transfer efficiency and aggravate under deposit corrosion .

There are two types of bacteria , the first is aerobic which require free oxygen for growth and anaerobic which grow in the absence of oxygen . The most common type of an aerobic is sulfate – reducing bacteria (SRB) [3], which convert dissolved sulfur compound(SO_4) to hydrogen sulfide (H_2S) . Carbon steel , stainless steel and copper – base alloys can be corroded severely by H_2S .

The aerobic sulfur bacteria , thiobacillus [3] can oxidize sulfur sulfides or sulfates to sulfuric acid (H_2SO_4) Localized pH depression as low as one can occur , causing severe general thinning of steel where these organisms contact the metal .

Theory of Biofouling formation and Control

1- Formation

Most studies [3,4,5] indicate that initial phase of slime development is the deposition of an organic coating on the wood or metal surfaces .When a clean piece of wood or metal put into water containing organics , the exposed surface is immediately conditioned by the adsorption of an organic film onto the material , then bacteria are transported to this area by the bulk water – organisms attach themselves by the production of polysaccharide exopolymers which provide a slimy , sticky mass which enables the deposit to trap other microorganisms as well as silt , scale and corrosion products as shown in fig (1) [3]

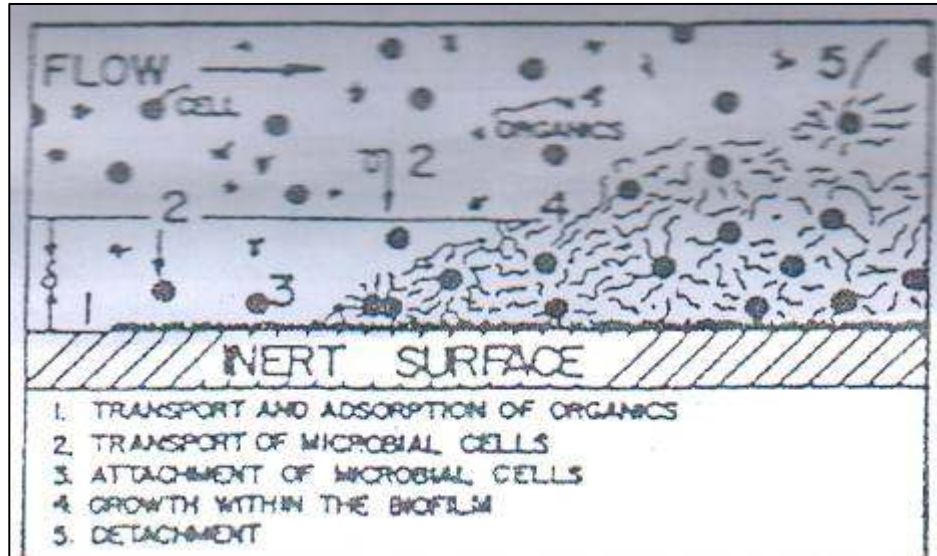


Fig (1) diagram describing fundamental process of biofouling accumulation [3]

After this initial stage of microbial attachment, the organisms continue to develop, multiply and produce polymers.

As deposit grows, shear forces, due to velocity of flowing water break off the film and the organisms within the film continue to multiply and rapidly regenerate the deposit, then aerobic and anaerobic conditions can develop causing corrosion problems fig(2) [3]

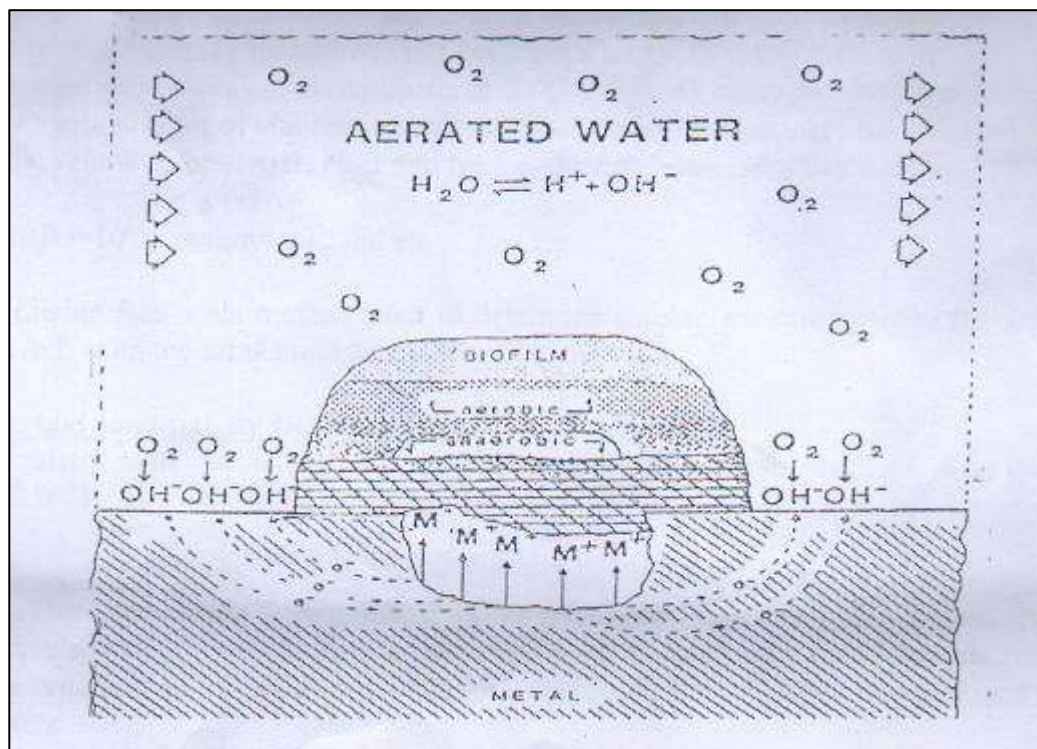


Fig (2) corrosion causes aeration cell due to biofilm development on a metal surface [3]

2- Control

Biocides is the most practical and efficient method used to control microbiological activity in cooling water.

These chemicals have the ability to inhibit organism growth and reproductive cycle . Biocides can be either oxidizing or non – oxidizing toxicants . Free chlorine released from Naocl is the most prevalent industrial oxidizing biocide . it rapidly hydrolyze in water to form hypochlorous (Hocl) and hydrochloric acid (Hcl)



Since the germicidal efficiency of hypochlorous acid is much higher than hypochlorite , the lower PH levels (below 8) in cooling towers are complementary to chlorine usage [6] . A general recommendation for chlorine use in cooling waters is to keep the free residual chlorine between 0.2 – 0.1 PPM in order to prevent wood deterioration and excess chemical usage [1,2,6,5] .

Laboratory measurements and test runs

1- Bacteria quantity measurements :

((A)) utilizing yellow vials method used to determine anaerobic bacteria (SRB type) quantity in column /ml | .

Procedure

- * At least 4 samples of yellow vials were taken and numbered .
- * 1ml of cooling water sample in yellow vial No. 1 with perfect mixing were injected .
- * 1ml of yellow vial No. 1 injected in vial No.2 with perfect mixing .
- * the third step for yellow vials No.3 and 4 was repeated .
- * then yellow vials were put in the incubator at 60 C for 24 – 48 hours
- * if the yellow color of vial No. 1 convert to black color the mean that SRB = 10 column/ml
- * if the yellow color of vials No. 1 and No. 2 convert to black color that's mean SRB = 10^2 column /ml. and etc

((B)) Utilizing red vials method used to determine aerobic bacteria quantity (or growth) in column /ml . with the same procedure steps of yellow vials .

2- Thermal conductivity determination

Many tests performed to determine conductive resistance of heat transfer in ($\text{m}^2 \text{C}^0 \text{W}^{-1}$)

3- Treatment test runs

This step include dosing different flow rates (PPm) of sodium hypochlorite (Naocl) , a principle source of free chlorine to determine the optimum concentration of this material to inhibit organism growth and reproductive cycle . then improve heat transfer efficiency

4- Typical data

* Naocl is an innovative product on the biocide Line for treating industrial water , it is gradually releases free chlorine guaranteeing effective action against both bacteria , algae and fungi .

- * Aspect ----- light liquid
- * Solubility in water ----- Complete in all proportions
- * PH of water solution ----- over 3.0

Results and Discussion

Table (1) shows the results of microbiological bacterial growth test

Table (1) results of SRB and acidophilic Growth test

Test no.	Anaerobic bacteria (SRB) column /ml	Aerobic bacteria (acidophilic) column /ml
1	10^2	10^2
2 after 30 days	10^3	10^2
3 after 30 days	10^6	10^2
4 after 30 days	10^7	10^6
5 after 30 days	10^8	10^7

The data of table (1) was taken in summer season , these data refer to rapid growth of bacteria in cooling tower due to appropriate environment for life – sustaining growth. Results of conductive heat transfer resistance versus fouling growth shown in table (2)

Table (2) heat transfer results with fouling growth

Fouling growth column column /ml	Conductive heat transfer resis tance ($m^2 C^{-1} W^{-1}) * 10^5$
10^2	20
10^4	37
10^5	43
10^7	58
10^8	63

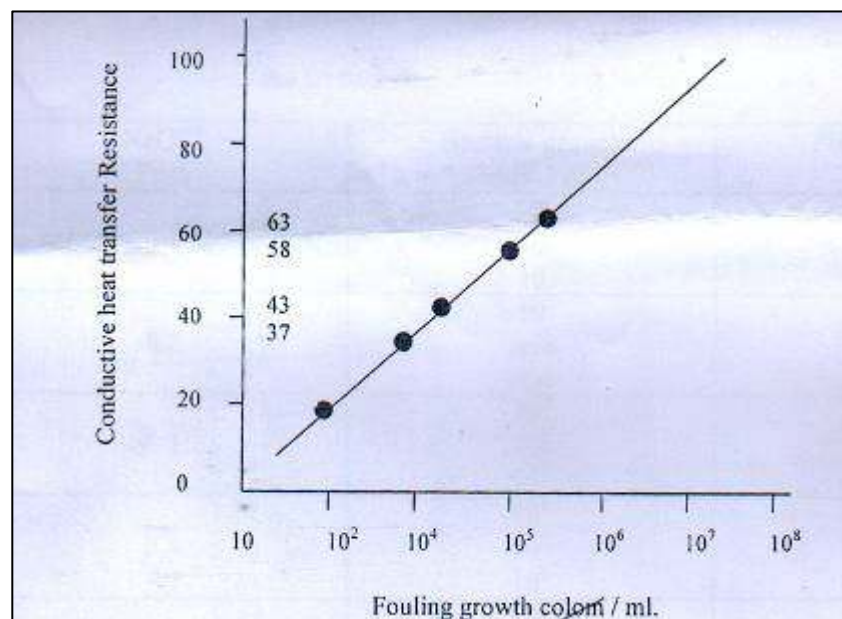


Fig (3) fouling growth vs. conductive heat transfer

Fig (3) shows the relation between bacterial growth and conductive resistance. Table (2) and fig (3) show that biological films exhibit poor heat transfer characteristics. Even a slight film on a heat transfer surface drastically reduces its cooling efficiency. Fig (3) shows that biofilms of about 10^2 - 10^5 column /ml can cause 10% to 50% reduction in heat transfer properties.

Effect of chlorine

Different concentration of sodium hypochlorite used to determine the optimum ppm of chlorine , these concentrations are 0.1,0.2 , 0.3 , 0.4 , 0.5 , ppm as a function of pH values cooling water .

Table (3) show results of bacteria quantity with different concentrations of Naocl with respect to pH values .

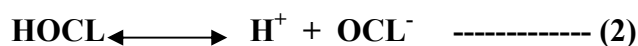
Table (3) bacteria growth results with Naocl concentration

Naocl ppm	Bacteria growth Column /ml	PH value
0.1	10 ² 10 10	6.5 – 7.3
0.2	10 Zero zero	7.2 – 7.5
0.3	10 ² 10 ² 10 ³	8.3 – 8.6
0.4	10 ³ 10 ³ 10 ⁴	8.6 – 9
0.5	10 ⁴ 10 ³ 10 ⁴	6 – 6.5

Results of table (3) show the relation between pH values of cooling water and free chlorine concentration .

Sodium hypochlorite (Naocl) release the free chlorine which rapidly hydrolyzes in water (equation 1) .

HOcl is the active species and dissociate as a function of pH



At pH 7.5 , equal concentrations of HOCL and hypochlorous ions (ocl) exist [6] .

Above this pH , the ocl predominates with essentially total ionization at pH 9.5 , chlorine become less effective in the more alkaline environments as shown in results of table (3) , the bacterial growth have high values at 0.3 – 0.4 ppm , for this reason, the concentration range 0.1 – 0.2 ppm and pH range 6.5 – 7.5 are considered the optimum condition used to control bacterial growth then to control scale and corrosion problems , and improve the cooling efficiency of cooling system . the results show that lower (pH)s will accelerate corrosion [7] .

Conclusions and recommendations

- 1- biological films exhibit poor transfer characteristics because of its insulating properties .
- 2- it showed that biofilm of about 10² – 10⁵ column/ ml can cause 10% - 50% reduction in heat transfer

- 3- chlorine is the most prevalent industrial oxidizing biocide has ability to inhibit organism growth .
- 4- the principle sources of chlorine are salts of hypochlorous acid such as (Naocl) which used in this research and calcium hypochlorite $\text{Ca}(\text{Ocl})_2$
- 5- it found that continuous treatment levels of 0.1 to 0.2 ppm are optimum at pH range between 6.5 – 7.5
- 6- it is recommend to perform a research which include a study of the relation between the amount of biofouling which caused by the presence of bacteria and amount of scales and corrosion using the coupons method

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