

## EXPERIMENTAL EVALUATION OF TURBIDITY REMOVAL FROM AL-EZZ RIVER

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### ABSTRACT

The turbidity of Al-Ezz river water has been removed in a pilot plant designed and constructed locally. The local lime, ferrous sulfate and polymer have been used as coagulants and the last as a coagulant aid with ferrous sulfate for different levels of turbidity. Chemical pretreatment of the river water was first investigated on a laboratory scale to optimize the coagulation and flocculation conditions with respect to the turbidity, and zeta charge indexes after sedimentation and filtration processes. Experimental investigations have been carried out in a pilot plant to determine the optimum dosages of coagulation and coagulation aid required to reach the permissible limits of turbidity. The results were discussed and compared with the worldwide standards where a good agreement has been observed.

### INTRODUCTION

Water has always played a prominent role in the human civilization. When people first began settling in one place and growing crops for sustenance, it was invariably near water sources. Towns and villages of Al-Ezz area rely almost entirely on Al-Ezz river for all water uses. Al-Ezz river is located in the southern Iraqi marshes between the latitudes 31 05 and 31 07. It starts from Amarah to Euphrates at Qurna with total length of 98 km and a mean annual discharge of 7 billion cubic meters (Al-Mahmood, 2002). The river water conventionally used for drinking was not considered as safe drinking waters. Many villages were identified as not having adequate drinking water source or had chemically (turbidity and brackishness) or biologically contaminated and hence were unfit for human consumptions as such. The characteristics of turbidity in surface water supplies are a function of many factors. Water stream features, such as geology, human development (i.e., agricultural uses or urban development), topography, vegetation, and precipitation events can all greatly influences raw water turbidity. Erosion of materials such as clay, slit or mineral particles from soils or from natural

organic matter by the decay of vegetation is one of the natural processes by which turbidity is created and conveyed to a raw water intake for a water treatment plant.

One of the physical characteristics of potable water that should meet the standards is turbidity. Turbidity is a measure of the cloudiness of the water. It is monitored because it is a good indicator of water quality. For the treated drinking water, turbidity must be kept below 1.0 NTU (nephelometric turbidity units) to ensure water safety for human consumption is not compromised (IISIR, 1993). The international guideline is that finished drinking water consistently measures 0.5 NTU, and that utilities set a goal of 0.1 NTU (AWWA, 1990). Levels higher than this may allow particles to shield or clump around the microbiological contamination, preventing the disinfectant chemicals, such as chlorine, from reaching and destroying the bacteria, viruses or parasites. Therefore, in turbid water, even though large amount of chlorine may be added, and even though residual levels of chlorine may be detected, the water can not be assumed to be safe to drink (Corkal, 1997). The size of colloidal particles are in the range of a few nanometers up to some hundred micrometers, usual colloidal particles in surface waters have sizes ranging from 0.001 up to 10 microns (Mahavi and Razavi, 2005). The time to settle down these particles ranging from a few minutes up to tens years (Smauel and Osman, 1983). With the aid of coagulants, and by the flocculation process, followed by sedimentation and filtration, these colloidal impurities can be actively removed from raw waters. Alum, lime, ferric chloride, ferrous sulfate and polymers are the most commonly used chemicals in turbidity removal processes these days (Tebbutt, 1998; and Mahavi and Razavi, 2005)).

The objective of this paper is to present and discuss the results of a study conducted on Al-Eiz river water for the removal of turbidity with chemical precipitation on laboratory as well as pilot plant scales.

## **MATERIALS AND METHODS**

Evaluation of turbidity removal from Al-Ezz river water was carried out on laboratory (jar test) and field (pilot plant) scale. Local lime, ferrous sulfate, local lime-ferrous sulfate mixture and magnafloc polyelectrolyte LT27 were used which the first three were mineral coagulants and the last was polymeric one.

The jar test experiments were performed in order to obtain basic data that were necessary for designing and planning the field study. Jar tests were conducted with raw waters taken from sampling station located near the connection point of Al-Ezz river with the Euphrates. The used dosages



of lime were in the range of (20-40) ppm and that of ferrous sulfate and magnafloc polyelectrolyte were (5-30) and (0.5-4) ppm, respectively. The chemicals were fast mixed with the river water at 250 rpm for 2 minutes followed by 30 minutes slow mixing at 70 rpm.

A small pilot plant system was built at a private desalination plant to allow the feed of coagulant chemicals for an extended period of time, monitor turbidities, and feed auxiliary reagents such acid or caustic for pH adjustment. The pilot plant has been constructed for trial operation on the treatment of surface water from Al-Ezz river. The main purpose of these particular studies is to establish confidence and operating stability in the proposed treatment scheme based on laboratory results. The flow scheme of the pilot plant is shown in Fig.1. The pretreatment section includes the following main treatment stages:

- Dosage and rapid admixture of chemicals
- Flocculation and sedimentation
- Dual media filtration
- Finished water reservoir

A turbulent zone in the mixing tank is required in order to obtain a rapid admixture of the flocculation chemicals in the whole water body. This is a prerequisite for good coagulation and flocculation. Other chemicals to be dosed in the plant are admixed rapidly in the water body by the installed in-line mixtures. The design flow rate of the flocculation and sedimentation units is determined by the settling area of the sedimentation tank and the recommended hydraulic surface load. The later should be in the interval of 1.0-1.5  $\text{m}^3/\text{m}^2.\text{hr}$  after chemical flocculation with a 3-valent metal coagulant (Sikora *et al.*, 1989). The design parameter of the flocculation stage is the so-called rate gradient rather than the flocculation time. The rate gradient, which is the measure of the energy input in the flocculation tanks, depends on the agitation rate, type of agitators and the flocculation time.

The dual media (sand-gravel) filters are of the open gravity type and have 1-5 mm and 5-10 mm support gravel in the bottom. Above this filter gravel there is a 300 mm layer of 0.4-0.6 mm green sand. As far as possible the grain should preferably be round and the uniformity coefficient not greater than 1.5. The filtrated water is collected in finished water reservoir.

The samples temperature and pH were measured in the field at the time of collection whereas turbidities of raw and finished waters measured immediately by using a handheld portable turbidity meter to the nearest  $\pm 5\%$  of full scale. All laboratory work was done according to standard method for the examination of water and wastewater (APHA, 1995).

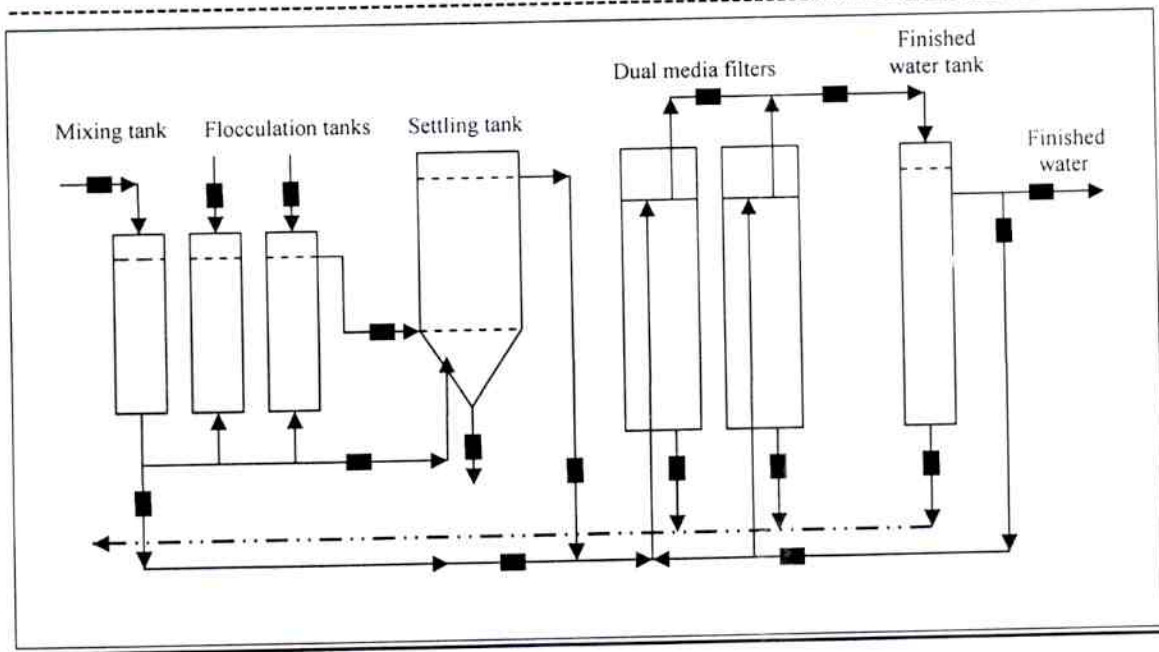


Fig. 1 Pilot plant flow scheme

## RESULTS AND DISCUSSION

The turbidity in streams and rivers is constantly changing phenomenon. The seasonal variation in the river water turbidity is shown in Figure (2) During dry periods, when no precipitation occurs, turbidity levels usually drop to a somewhat stable value for the river. A precipitation event in the water stream can then bring additional suspended material into the stream and greatly increase the turbidity. Generally, the more intense the precipitation event, the higher the turbidity values experienced in the stream. According to the rivers classification, Al-Ezz river considered as a high turbidity river since its average turbidity value greater than 20 NTU (EPA, 1999). It is advisable to design the plant for maximum feed water turbidity and vary the chemical dosages from season to season.

In order to determine the optimum addition of coagulant chemicals, a number of experiments were carried out with the laboratory scale, the zeta potential of colloids being used as a parameter to determine the exact addition. These experiments were based on the general concept that the best results is obtained with zero zeta potential (Schippers *et al*, 1980). Figures (3 and 4) show the zeta potential of the colloids present in the influent of the pilot plant against the addition of ferrous sulfate and magnafloc LT27. On the basis of these result, the optimum dosages of ferrous sulfate and magnafloc LT27 were 20 and 1.8 ppm, respectively.

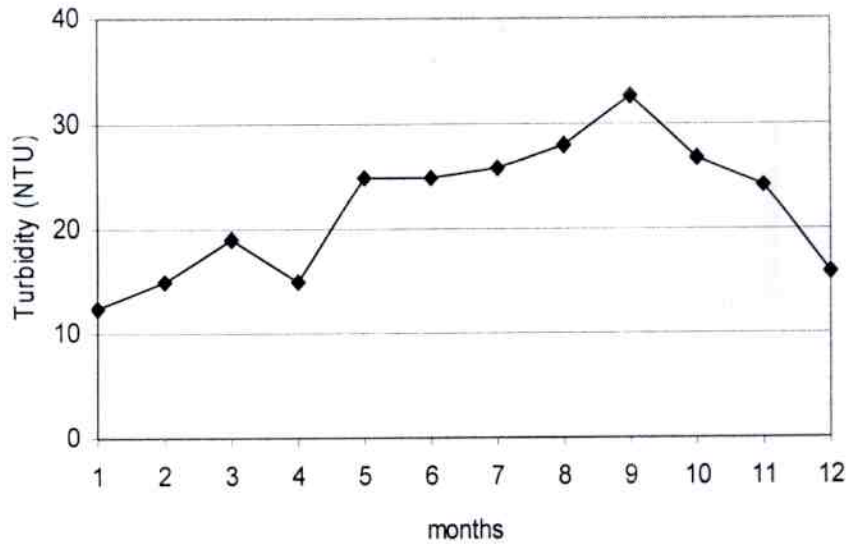


Fig. 2 Seasonal variation of Al-Ezz river water turbidity (2004)

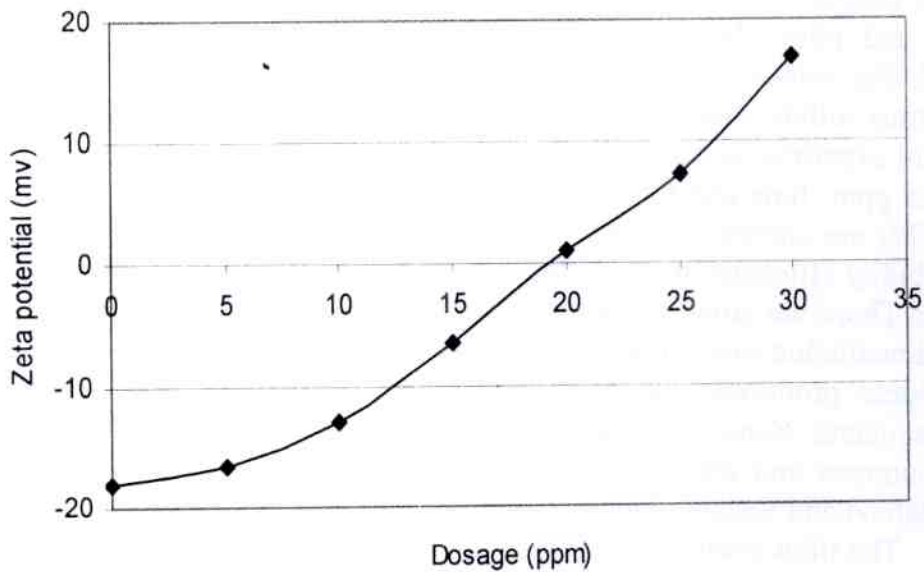


Fig.3 The zeta potential of the colloid in the raw water as a function of the dosage of ferrous sulfate.



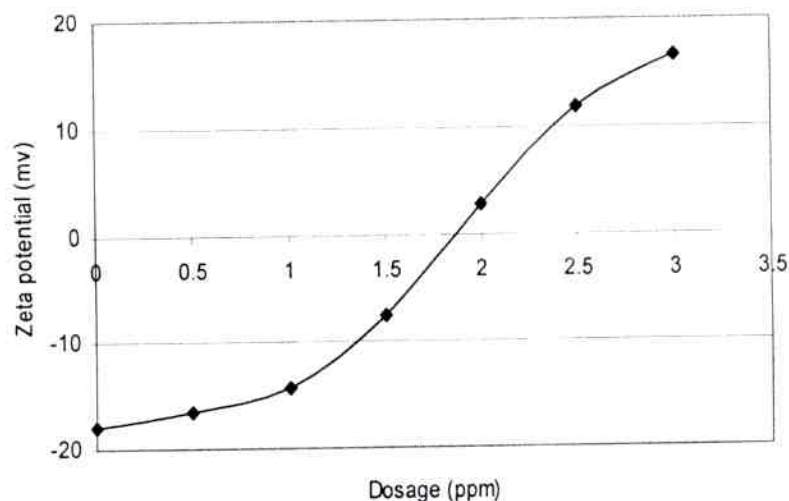


Fig. 4 The zeta potential of the colloides in the raw water as a function of the dosage of LT27

Local lime can be used alone as a coagulant with medium and high initial turbidity levels, while better results have been obtained when it used as a coagulant aid with ferrous sulfate at low initial turbidity limits in both jar and pilot plant tests. The optimum dose required to achieve 93% turbidity removal in the jar test consists of 20 ppm lime with 7.5 ppm ferrous sulfate (Hasan and Al-Tamir, 2003). The results of jar test and pilot plant experiments; using 20 ppm lime (LL), 20 ppm ferrous sulfate (FS), 20 +7.5 ppm lime and ferrous sulfate mixture (LFS), and 1.8 ppm magnafloc LT27; are shown in Figs.5 and 6. The results show that the sequence of turbidity efficiency removal for these coagulants is as:  $LT27 > FS > LFS > LL$ . There are some advantages in the usage of polymers such as: higher sedimentation rate, lower price, better finished water quality, lower sludge volume produced, and a better sludge quality with respect to mineral coagulants. Some disadvantages are related to the polymers such as the monomers and residues in finished water which may be a health hazard (Mahavi and Razavi, 2005).

The pilot plant results (Fig.6) indicate that the results for the four used chemicals are better than what has been obtained in the jar test. The differences in turbidity efficiency removal for the same chemical dosages between the jar test and the pilot plant are attributed to factors such as mode of operation, hydraulic load, and type and rate of agitation.

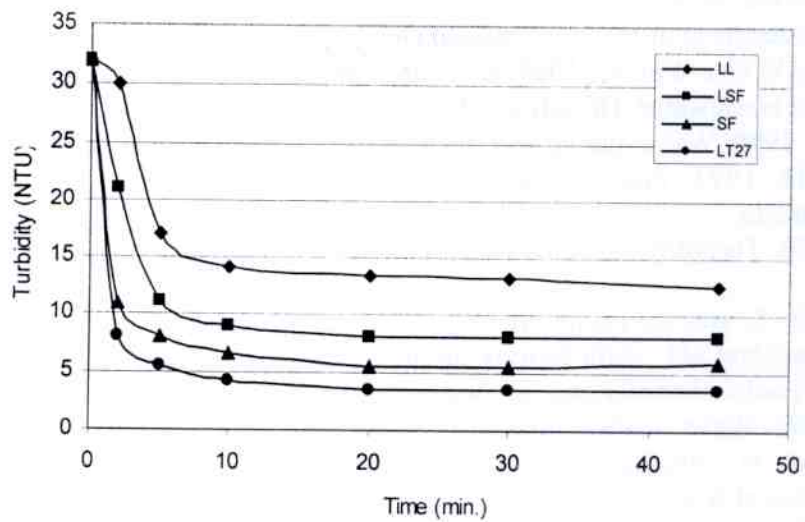


Fig. 5 Performance of coagulants in jar test

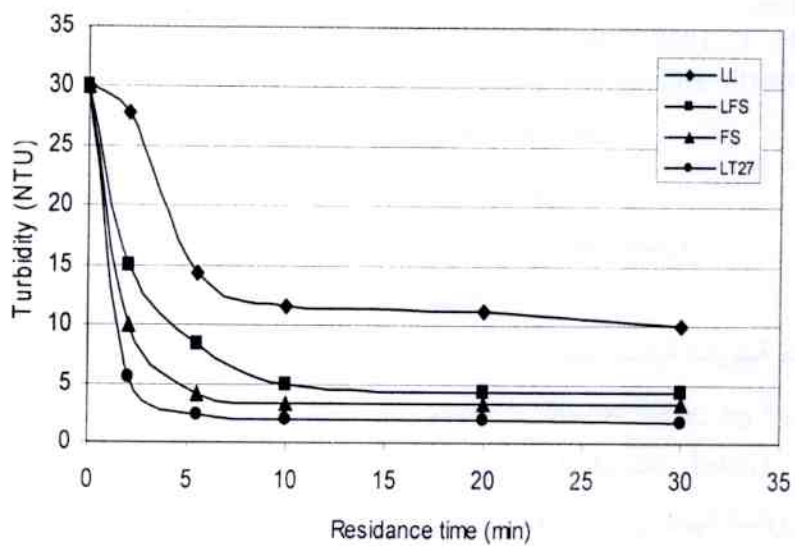


Fig.6 Performance of coagulants in pilot plant

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### إزالة العكورة من مياه نهر العز

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#### الخلاصة

درست عملية ازالة العكورة من مياه نهر العز باستخدام وحدة تصفية تجريبية صممت محليا لهذا الغرض. استخدمت النورة المحلية كمختر مستقل او كمساعد للتخثير مع كبريتات الحديدوز وقورنت النتائج مع تلك التي تم الحصول عليها عند استخدام كبريتات الحديدوز بمفرده ومختر بوليميري معروف. تم تقييم كفاءة المخترات المستخدمة اعتمادا على كمية العكورة المزالة وتم تحديد الجرعات المثالية مختبريا باستخدام مؤشر زيتا. نوقشت النتائج وحللت حيث اعطت تطابقا جيدا مع تلك المستحصل عليها عالميا.