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# WASTEWATER MEASUREMENT AND CHARACTERIZATION: DATA PROCESSING

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***Abstract***– The increasing of industrial and civil activities produces changes in the quality of water discharged in land, and in rivers/seas, and surface water. Every activity needs a water treatment plant. The quality of water must be conform to specific technical legislation. In order to control the quality of wastewaters, some efficient techniques are requested especially in presence of solvents and suspended solids. A spectroscopic method is proposed along with a statistical approach for validating data.

***Keywords***: Environmental measurements, absorbance and transmittance characterization, wastewater quality, spectroscopy, optical fiber

## 1. INTRODUCTION

Wastewaters produced by urban agglomerations are generally treated by means of biological processes while industrial wastewaters need a chemical treatment or a chemical-biological process. But, these wastewaters mostly contain solvents to be eliminated or at least reduced. In presence of solvents that can produce a contamination on environmental matrices, a monitoring is requested. One of the most interesting techniques is related to the use of optical methods for characterizing liquids and gas. The most important optical methods are: spectral analysis in absorption, UV spectrophotometry and colorimetry, IR spectrophotometry, analysis in emission and absorption, refractometry and polarimetry. If a substance is under the action of electromagnetic radiation (ER), the radiating energy contained in the ER can be absorbed by molecules to be transformed in other forms of energy. Two important parameters are used for spectral analysis in absorption: transmittance and absorbance or extinction. Given a medium X with incident light intensity $I_0$ while $I_x$ is the output light. If $I_s$ is the intensity of reference solution [2], transmittance [3] is defined the ratio $I_x/I_s$ that is only related to the substance under test, and it is the sole parameter to be taken in consideration in case of analysis of dissolved substances:

$$T = \frac{I_x}{I_s} \tag{1}$$

One should note that, given that $0 \leq I_x \leq I_s$ we have also $0 \leq T \leq 1$, that is the transmittance is a number comprises between zero and one, and in common use is expressed in percentage. Value 1 characterizes materials which are transparent, that is, in chemical analysis, solution with zero concentration (pure solvent). Value 0 is typical for matt or hypothetical solution with infinite concentration. The second interesting parameter is the absorbance or extinction [1] that is defined as the decimal logarithm of the reciprocal of the transmittance

$$A = \log\frac{1}{T} = \log\frac{I_s}{I_x} \tag{2}$$

The range of transmittance variation is 0 and ∞ corresponding to values 1 and 0 of transmittance. Absorbance is very important because it has a linear relationship with the concentration. The basic law of analysis in absorption establishes a relationship between absorbance and concentration, that is the Lambert-Beer’law [4] written in another way

$$A = a\,b\,c = \log\frac{I_s}{I_x} \tag{3}$$

where ***a*** is the extinction coefficient, *b* the thickness of the liquid or gas through which the light passes, and *c* the concentration of liquid or gas. The extinction has a particular meaning when we set $b=c=1$, then the extinction is equal to absorbance. The extinction is a characteristic of various substances $\lambda$, being high when the substance absorbs and low in spectral regions where the substance is transparent. The variation of ***a*** in function of $\lambda$ is the basic idea of qualitative analysis.

Quantitatively speaking, concentration is expressed in *g*/*l* and the thickness in cm, the coefficient ***a*** is then expressed as

$$a = \frac{A}{b.c} = \left[\frac{1}{cm.g/l}\right] = \left[l.cm^{-1}.g^{-1}\right] \tag{4}$$

If the concentration is expressed in molarity [5], the extinction coefficient usually indicated as $\varepsilon$, and is called as molar extinction coefficient, that has the following dimensions

$$a = \frac{A}{b.c} = \left[\frac{1}{cm.g/l}\right] = \left[l.cm^{-1}.g^{-1}\right] \qquad (5)$$

Graphical representation of transmittance in function of concentration is an exponential plot, asymptotical with respect to axis of *c*. On the contrary, the absorbance linearly varies with the concentration, and in fact it is defined by means of a logarithmical function in order to establish a linear relationship with concentration.

## 2. EXPERIMENTAL ACTIVITIES

We proposed an experimental setup that is shown in Fig. 1(a). Due to the different size of the hydrocarbon microparticles a broad white lamp source (Halogen light source HL-2000-FHSA Mikropack) is used; in this manner it is possible to observe a “macroscopic” effect because a lot of wavelength will interact with the microparticles. The lamp source is coupled to a multimode optical fiber fixed on a holder micrometric stage. At the same height of the optical fiber source is fixed an optical fiber receiver directly connected to a high sensitive optical multichannel analyzer (OMA). We observe that the distances d1 and d2 of Fig.1 (b) are tuned in order to improve a sufficient light collected by the receiver fiber. Due to the high sensitivity of the OMA and to the big dimension of the sample we do not use a telescope system as used for integrated optical waveguides or bulk type materials, where a good collimated light is required

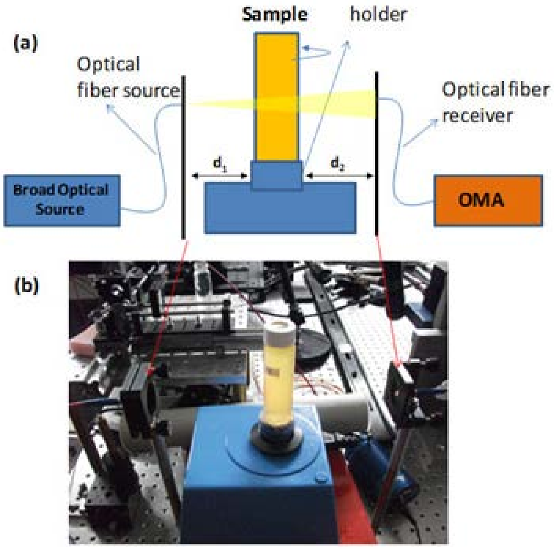

Fig. 1. Example a) Schematic illustration of the experimental setup. The light source region is defined by the light cone. (b) Photo of the used experimental setup.

The samples are quoted white and polluted with hydrocarbons. To simulate the flow of water in a turbulent condition, the sample is under vibrations using a controlled driver. The white sample (reference sample) is characterized (Fig.2) in two conditions: moving and stop. The trend of intensity, using Eq.(3) versus wavelength is illustrated. Different vibration effects are indicated in Fig.3

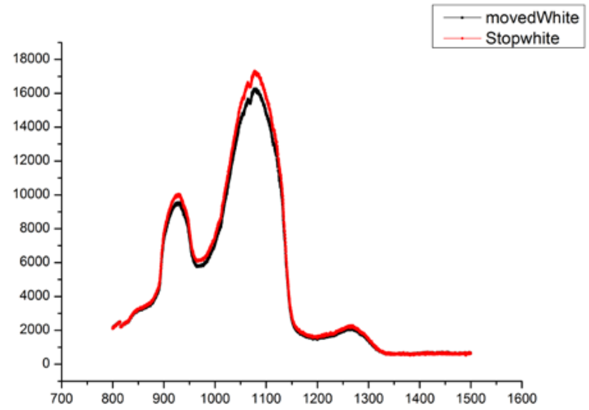

Fig. 2. Intensity vs wavelength for a white sample

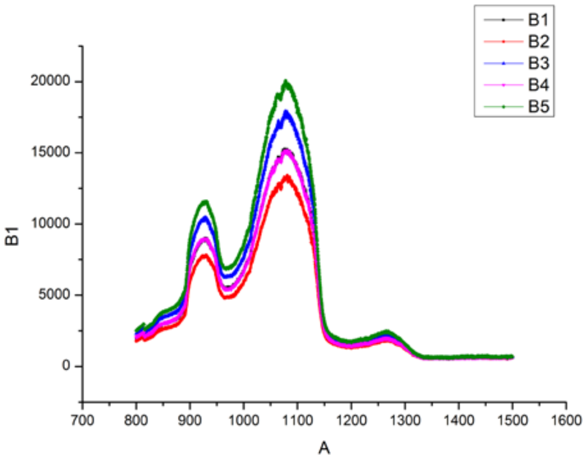

Fig. 3. Intensity vs wavelength of white sample at different rotations.

## 3. RESULT PRESENTATION

The main idea of the experiments is to detect the quantity of hydrocarbons in the water at different turbulence conditions. It is not easy to detect a precise concentration in a turbulent flow; it is easy to do that in laminar flow.

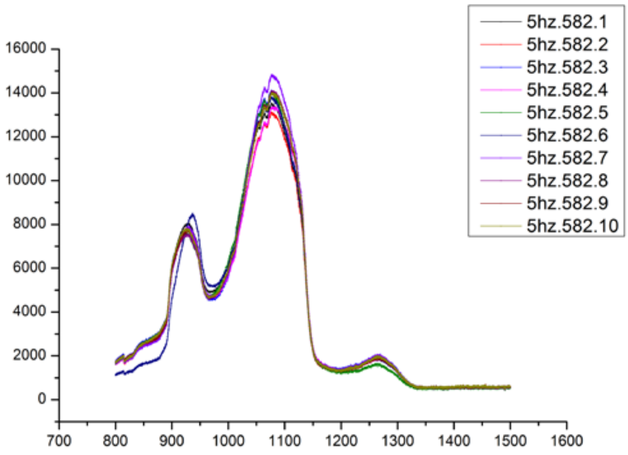

Fig. 4. Ten trials of spectroscopic measurements at different operating conditions around 5 Hz of vibrations.

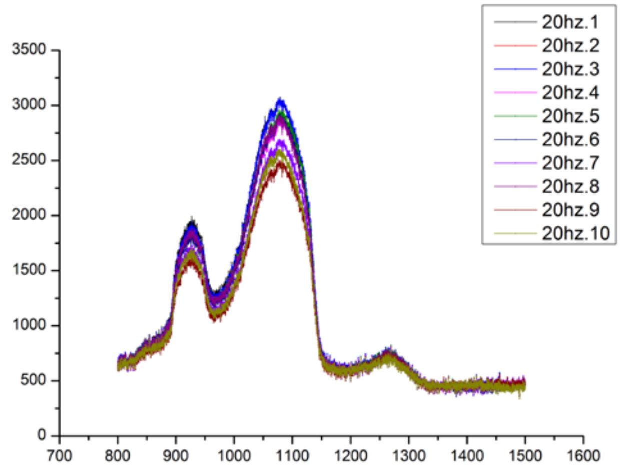

Fig. 5. Ten trials of spectroscopic measurements at different operating conditions around 5 Hz of vibrations

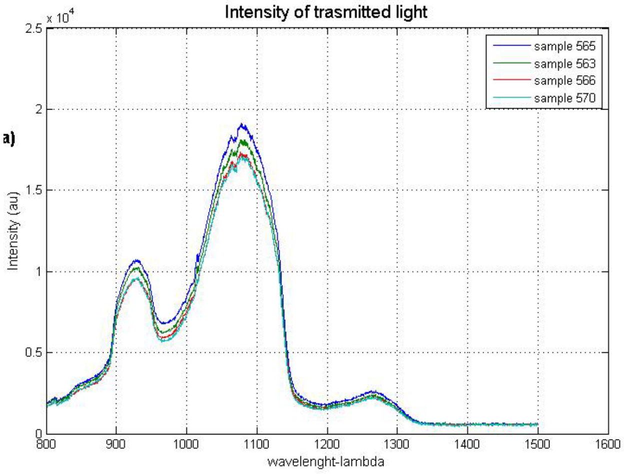

Fig. 6. Intensity vs wavelength for diverse polluted samples

The experimental activities have involved many samples of polluted water containing hydrocarbons. Fig.4 and Fig.5 illustrate the trends of intensity vs wavelength. The experimental trials have been repeated by using different samples (Fig.6) and the trend is the same despite the magnitude of the concentration; this is the main finding of the proposed work. In general, for non laminar flow, changes occur in the trend and in the quantity of results.

## 4. CONCLUSIONS

According to the experimental setup, we have characterized different samples with different concentrations of hydrocarbon. The kinds of hydrocarbon are $C_{14}$ and $C_{40}$, respectively. Concentrations of hydrocarbons, as validation, have been determined by means of mass spectrometer mod. 5974 Agilent and chromatographic gas 6890 Agilent; both instruments are illustrated in [6]. Fig.7 depicts the trends of absorbance in function of wavelength that reflect those of found by means of traditional instrumentation of [6]. In conclusion we have demonstrated that the experimental setup yields to the same results of traditional instrumentation especially in the characterization of turbulent fluids that do not permit a quiet sampling and characterization.

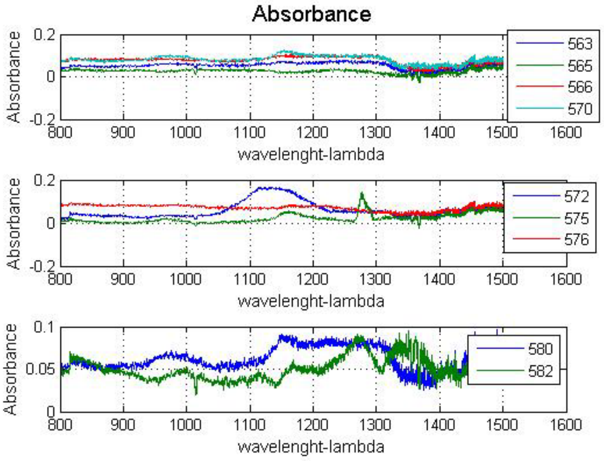

Fig. 7. Absorbance vs wavelength for different samples.

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