GEOMATE Journal Review and Evaluation

Paper ID number

54723

Paper Title

ASSESSMENT CORRELATION OF TOTAL SUSPENDED SOLIDS (TSS) BASED ON DRIED AND SENSOR METHOD

i. Originality

5 (Excelent)

ii. Quality

5

iii. Relevance

4

iv. Presentation

4

v. Recommendation

4

Total (sum of i to v)

22

General comments

Generally, this paper has been matching with minimum requirement for research paper but some revision or additional explanation is required to improvement quality of this research/paper.
Before accepted, some correction and improvement are recommended;
1. Some formatting must to be improved since spacing still connecting with previous sentences.
2. Water quality of the water shall be expressed to this paper to setup limitation of the formula resulted from this paper.
3. Picture number 6 need to be changed to two pictures since both lines are different scale. Give explanation both pictures respectively.

Mandatory changes

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Suggested changes

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General comments

This paper presents some interesting results. It is
a good quality paper. It can be recommended for
journal publication with some minor revisions.

Mandatory changes

1. Use of however or so . No need to use two
adverbs or conjunctions together
2. Check the word spaces in the whole text.
Spaces are missing in some cases
3. The descriptions of fig. 4 and 5 are not enough
in the result and discussion section
4. Figure 3: The text inside the figure, X- and Y-axes
values, Legends
are not clear. Improve the resolution of the figure.
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Mandatory changes

1. Formatting manuscripts need to be improved
2. Picture 6 need to be changed into twice picture and giving brief related this picture
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ASSESSMENT CORRELATION OF TOTAL SUSPENDED SOLIDS (TSS) BASED ON DRIED AND SENSOR METHOD

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*Corresponding Author, Received: 21 May 2020, Revised: 00 Nov. 2018, Accepted: 00 Dec. 2018

ABSTRACT: In order to maintain water quality standard due to mining activity, a very strict control is required on the water coming out into environment. In the field, water quality is assessed by using a portable Total Suspended Solids (TSS) measuring device that results are usually different from laboratory test results. Laboratory test produces accurate TSS values, but requires considerable time. Based on these conditions, it is necessary to study the comprehensive correlation between TSS results measured in the field by using portable device and the results by laboratory test. This study was conducted to determine correction of TSS measurement in the field by correlating it to the measurement in the laboratory. The same samples were used for both measurement methods and measured in unit of mg/l. Correction of TSS measurement using portable device was obtained by building a model of the relationship between TSS by device with TSS by laboratory test. Regression method was applied to obtain the calibration model. There were two portable devices using in this study, namely Partech 740 and DR900, so two models were built. Candidates for the models were constructed based on the grouping of relative error data resulted by each device. The models with the smallest mean absolute error (MAE) were selected as relatively fair model, which were $TSS_{Lab} = 0.0435\ TSS_{Partech\ 740} + 66.86$ for Partech 740 and $TSS_{Lab} = 0.6116\ TSS_{DR900} + 85.46$ for DR900, with MAE value of 30.38 and 30.92 respectively.

Keywords: TSS, Dried Method, Relative error, Regression

1. INTRODUCTION

Mining activity, especially open-pit mining, has potential to increase value of total suspended solids (TSS). However, if it is managed properly, water quality standard would be reached before the water is released into the environment. In order to ensure that the water has quality standard complying with law and regulation, continuous monitoring is required. TSS is measured by using a portable TSS meter in field and periodically tested in laboratory. The TSS values obtained from field measurement are usually not the same as the value from laboratory test. For this reason, a study is required to examine the correlation between TSS measured in field by portable device and TSS tested in laboratory, so that it may be used as a reference in controlling field activity.

The composition of TSS may include sand, silt, clay, mineral precipitates, and biological matter. The clay is commonly found as illite, kaolinite, or montmorillonite [1]. TSS formation primarily depends on physical processes driven by hydrology. Processes that generate TSS in streams include erosion of adjacent surface soils and stream banks, scouring of the streambed, and aggregation of dissolved organic matter or chemical precipitation of inorganic solids within the water column [2]. In addition to ensuring that a representative sub-sample is collected, collection of the initial sample must be representative of the water body being tested. For testing of stormwater discharges from construction sites and utility pits, the sample should be collected at the end of the pipe for a sample that most closely matches the discharge that will be entering the water body [3].

Suspended solids sensors are typically factory-calibrated in unit of mg/L of ppm by using suspensions of weighed solid in water. Diatomaceous Earth (DE) primarily composed of silicon dioxide (SiO_2) is commonly used. Total suspended solids (TSS) is measured in laboratory by filtering a known volume of a sample, drying the filer and captured suspended solids in the sample. Total suspended solids (TSS) is a laboratory gravimetric procedure where the solids from the water sample are filtered through a 47 mm glass fiber filter, dried and weighed to determine the total non-filterable residue (TNR) of the sample reported as mg/L. TSS (in mg/L) is calculated as in

$$TSS = \left(W_{fss} - W_f\right)/V_s \quad (1)$$

where W_{fss} is weight of filter with suspended solids, W_f is weight of the filter, and V_s is volume of sample.

The entire process takes about 2 hours (or more) and does not lend itself to instantaneous, continuous measurement. The laboratory test refers to ASTM D5907 [4], EPA Method 160.2 [5], Standard

Methods 2540D [6], or similar gravimetric method for details of the lab method. Constraint of linear relationship between TDS and TSS loads is not constant or proportional over time or space; therefore, a single ratio would not be a reliable predictor of TDS load based on TSS load (or vice versa) for individual points in time or space [7]. Total suspended solids (TSS) is often the primary parameter available for estimation of sediment loads; therefore, it is important to have a reliable test for TSS. An alternative way to calculate the concentration of suspended solids is by the suspended solids concentration (SSC) test [8].

No measurement can be completely free of uncertainty, including uncertainty in scientific measurement that is called error. Errors in scientific measurement are inevitable and cannot be eliminated, so the best that can be done is to ensure that the errors are as small as reasonably possible and to have a reliable estimate of how large they are [9]. In order to achieve consistency of measurement, it is fundamental to carry out calibration. One of the most frequently used statistical methods in calibration is linear regression by establishing the relationship between an instrument response and one or more reference values [10]. The precision of the sensor was comparable to the standard method laboratory test, the accuracy showed a significant different between the average values of the laboratory-analyzed and sensor reported result. The sensor showed precision comparable to the standard laboratory method, though it was not accurate. Its accuracy did fall within the accuracy of the standard laboratory method, however so it may be able to be used as initial testing of run off before determining whether samples need to be sent to laboratory analysis [11]. TSS & TDS is having linier correlation but number of correlations is specific on each location [12]. Solid treatment efficiency in the long term for specific polluting load was shown in increasing during the first events but the decreased constantly [13].

2. RESEARCH METHOD

Sampling was carried out in two different locations with 15 samples taken in each location. Samples were taken at mine dewatering pump outlets at different time. Each sample was divided into 3 parts for testing. Total Suspended Solid (TSS) was measured by three methods that are Partech, DR900, and laboratory test. Many different total suspended solid s sensors and probes has been developed for rapid TSS measurement but Partech 740 and DR900 are portable TSS meter used for this research. Measurement of TSS by using portable devices was carried out by inserting a sensor into a glass containing sample of water that would be measured in TSS for two different TSS meters (Fig.1).

Fig.1 Field measurement of TSS by using portable device (Partech 740)

The portable TSS measuring devices have an accuracy of 0.1 mg/L and the probe has an operating concentration range of 0 – 20.000 mg/L for Partech 740 and 0 – 750 mg/L for DR900.

TSS measurement in the laboratory was carried out by using gravimetric method referring to [5-6, 14]. The solids from the water sample were filtered through a 47 mm glass fiber filter, dried, and weighed to determine the total non-filterable residue (TNR) of the sample reported as mg/L. A well-mixed, measured volume of a water sample was filtered through a pre-weighed glass fiber filter. The filter was heated to constant mass at 104 ± 1 ºC and then weighed. The mass increase divided by the water volume filtered is equal to the TSS in mg/L.

Referring to [6], water sample was stirred with a magnetic stirrer, and a measured volume was pipetted into the filtration apparatus. The total volume of sample filtered should leave at least 2.5 mg of residue on the filter paper, but no more than 200 mg residue. Filter was washed with three 10 mL successive washes and dried for one hour at 103 to 105°C, then cooled in a desiccator and weigh. The weight retained on the filter paper divided by the volume of sample filtered is the total suspended solids (TSS) concentration.

Measurement of TSS based on laboratory test is believed to be more accurate than using sensor. For this reason, in this analysis, TSS value by laboratory test was considered to be actual value. Both accuracy and precision of the measurement by devices can be calculated through relative error which is the difference in the value by sensors (measured value) and the value by laboratory test (actual value) compared to the value by laboratory test as the actual value (Eq. 2).

$$\text{Relative error} = \frac{|\text{Measured} - \text{Actual}|}{\text{Actual}} \quad (2)$$

The more similar the value by sensor with the value by laboratory test, the smaller the relative error, or in other words, the more accurate the sensor. Percent error which is the relative error multiplied by 100% shows how far the error resulted by the sensors is compared to the actual value. Precision of the measurement can be known by comparing standard deviation of the relative error to its mean.

Error pattern resulted by either Partech 740 or DR900 was further known through summary statistics and histogram. TSS data by each device was grouped into three based on the deviation from the average as shown in Fig.2.

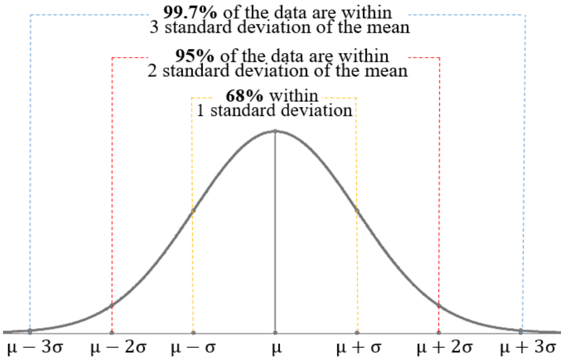

Fig.2 Grouping data under a normal curve that lie between 1, 2, and 3 standard deviation on each side of the mean

Calibration was performed by using regression method on each group of data that had been formed to estimate the pattern of relationship between TSS value by each device and TSS value by laboratory test. This relationship can be used to estimate TSS value by laboratory test based on the value from the sensors by Eq.3.

$$y = \text{a} + \text{b}x \quad (3)$$

where y is actual value (from laboratory test) and x is measured value (from sensor). a is a constant, while b is a coefficient of regression.

3. RESULT AND DISCUSSION

Table 1 shows the relative error of Partech 740 and DR900. The relative error of DR900 was much smaller than that of Partech 740; it means that DR900 was more accurate inasmuch as it was much closer than Partech 740 to the value by laboratory test. From Table 1, it can also be seen that the variation in the relative error of each device was not too large.

Table 1 Relative error of Partech 740 and DR900

Sample	Relative error of Partech 740	Relative error of DR900
1	19,48	0,124
2	18,4	0,136
3	19,19	0,33
4	20,65	0,52
5	20,61	0,477
6	22,3	0,543
7	21,23	0,566
8	18,28	0,416
9	19,08	0,448
10	18,66	0,397
11	19,53	0,499
12	21,23	0,682
13	19,99	0,412
14	19,37	0,381
15	18,79	0,389
16	15,29	0,004
17	15,51	0,148
18	16,62	0,447
19	18,35	0,232
20	13,58	0,289
21	17,59	0,391
22	16,15	0,059
23	16,68	0,155
24	16,82	0,238
25	17,51	0,257
26	17,59	0,314
27	17,97	0,15
28	16,57	0,191
29	16,83	0,174
30	14,4	0,022

In order to find out more about the relative error of both sensor, summary statistics (Table 2) and histograms (Fig.3) were made.

Table 2 Summary statistics of relative error for Partech 740 and DR900

	Relative error of Partech 740	Relative error of DR900
Mean	18.14	0.313
Variance	4.33	0.030
Std. deviation	2.08	0.174
Min. value	13.58	22.30
Max. value	0.004	0.682

The averages of relative error for Partech 740 and DR900 were significantly different that were 18.14 and 0.313, as shown in Table 2. It means that TSS value by Partech 740 deviated on average of 1,814% from the actual value – very far from the actual value compared with TSS value by DR900 that deviated on average of 31.3% from the actual value. Therefore, DR900 was more accurate than Partech 740 due to its mean of relative error which was much smaller. However, Partech 740 appeared to be more precise than DR900, known from its standard deviation compared to its mean which was smaller than that of DR900. Variability of relative error for Partech 740 ranges from 13.58 to 22.30, while for DR900, it ranges from 0.004 to 0.682. Visually, the variability can be seen from the narrowness of normality curve as in Fig.3. Fig.3 shows histograms of relative error for Partech 740 and DR900 with an addition of normality curve. Both data followed normal distribution according to the Shapiro-Wilk normality test with a significance level of 5% that resulted p-values of 0.994 and 0.691 respectively for Partech 740 and DR900. Partech 740, which had previously been described as more precise than DR900, had a narrower curve than the DR900.

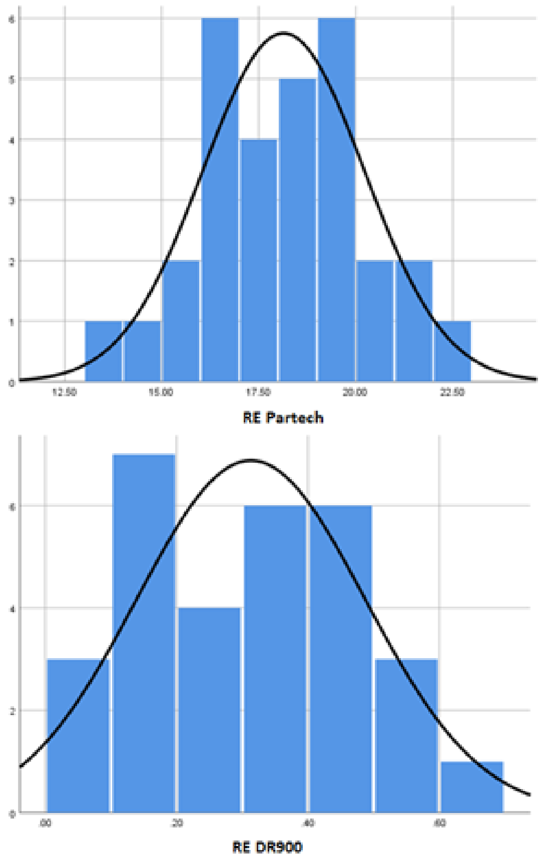

Fig.3 Relative error histogram of Partech 740 (top) and DR900 (bottom)

By considering the relative error data distribution, three types of calibration models for each device were constructed: involving 100% data, 95% data, and 68% data. The results are presented in Fig.4 for Partech 740, and Fig.5 for DR900.

Calibration models of Partech

Model based on	Excluded sample no.	Calibration model	MAE
100% data	-	$y = 0.0439x + 68.60$	30.86
95% data	20	$y = 0.0435x + 66.86$	30.38
68% data	4, 5, 6, 7, 12, 16, 17, 20, 30	$y = 0.0466x + 49.75$	32.20

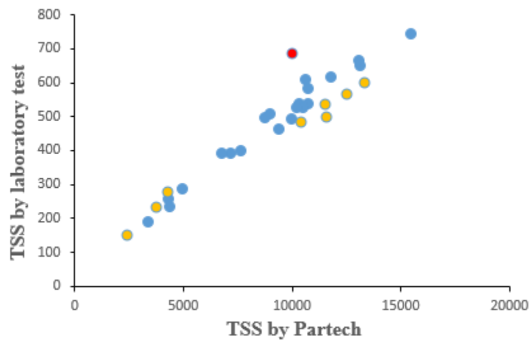

Fig.4 Plot of TSS value by laboratory test against TSS value by Partech 740 as well as the excluded data points on model 95% (red) and 68% (yellow)

Calibration models of DR900

Model based on	Excluded sample no.	Calibration model	MAE
100% data	-	$y = 0.5915x + 94.74$	31.08
95% data	12	$y = 0.6116x + 85.46$	30.92
68% data	1, 2, 4, 6, 7, 11, 12, 16, 22, 30	$y = 1.4859x - 71.81$	33.24

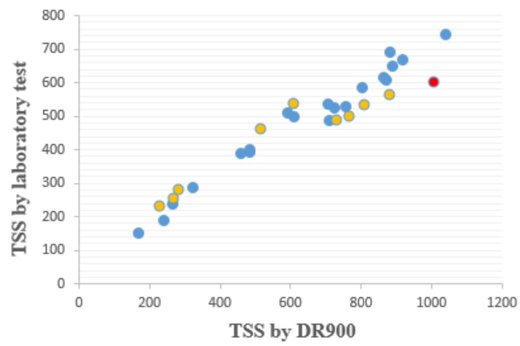

Fig.5 Plot of TSS value by laboratory test against TSS value by DR900 as well as the excluded data points on model 95% (red) and 68% (yellow)

For each model constructed, mean absolute error (MAE) was calculated. For each sensor, the model with lowest MAE among all was chosen as a calibration model that was considered to be relatively fair. The second model, either for Partech 740 or DR900, had the minimum MAE. Therefore, for both sensors, the second model, which was a model with the data of relative error included in the interval of 95%, was chosen (Fig.6). Based on the explanation above that each sensor having different correlation with TSS resulting from laboratory test with other sensor. Also, each sensor is shown different number to calculate same sample.

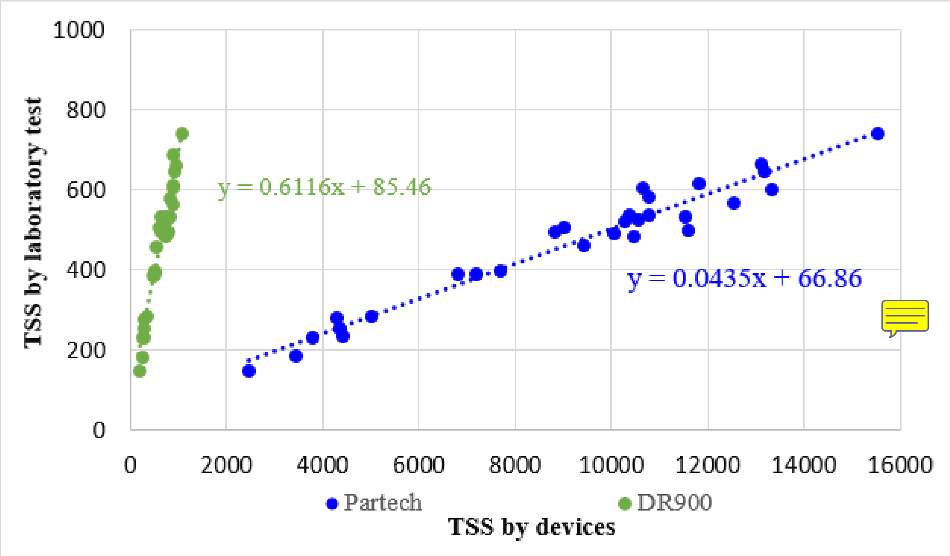

Fig.6 Calibration model for Partech 740 and DR900

4. CONCLUSION

Measuring Total suspended solid (TSS) using sensor is shown accurate but it's can be applied on field before sample sent to the laboratory. Total suspended solid (TSS) value measured by sensors, which are Partech 740 and DR900, can be converted to approximate the actual value (TSS by laboratory test) through the following equations:

$$\mathbf{TSS_{Lab} = 0.0435\ TSS_{Partech} + 66.86}$$
$$\mathbf{TSS_{Lab} = 0.6116\ TSS_{DR900} + 85.46}$$

However, it should be noted that the average deviation from the actual value, expressed with mean absolute error (MAE), produced by the two models are 30.38 and 30.92. Completely accurate calibration model is difficult to construct due to the random errors.

Further testing is required to confirm the result of the analysis due to of the minimal amount of sample used in this analysis. Detailing water quality is also recommended to guideline application the correlation formula has been established above.

5. ACKNOWLEDGMENTS

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