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# Pipe Mills Companies Water Quality Monitoring and Management System Design (Case Study: Ahvaz Pipe Mills Company)

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**ABSTRACT:** Ahvaz pipe mills company is located in the south eastern oil fields in Khouzestan province. This company includes three plants of steel pipes and two coating plants. The present research has been conducted in two stages for methodology of cluster analysis application in monitoring program design of Ahvaz pipe mills company from November 2007 to August 2008. In the first stage, samples from 22 selected stations were chosen and 14 wastewater qualitative parameters were measured and compared with national standards of wastewaters discharge (DOE), and in the second stage monitoring system of wastewater qualitative was designed. Then cluster analysis test was used for surveying similarity of stations (about each of parameters separately) and the design of monitoring program. Comparing the average of the results of the investigated parameters in wastewater with national standard of wastewaters discharge in total time of sampling indicated that the amounts of TSS, $BOD_5$, COD, $SO_3^{-2}$, $Cl^-$ and $Ca^{+2}$ parameters are higher than the standard limit. The results of cluster analysis test for similarity survey of stations (about each parameter separately) in total time of sampling indicated that sampling stations have significant difference only in temperature and COD parameters. Besides, cluster analysis was performed for classification of similar stations considering all of the studied parameters in total time of sampling in order to design of monitoring program. Based on this approach 7 separate groups obtained including 7 stations that in each group one station was index that they introduced as monitoring stations then provided the position map of final monitoring stations. Finally, in continuation of monitoring program design, parameters on the basis of sensitivity and importance were divided into three sampling program ( daily, weekly and monthly ).

***Keywords*:** Cluster Analysis, Monitoring program, Water quality, Ahvaz pipe mills company.

## INTRODUCTION

Nowadays, the use of resources and production of industrial waste such as wastewater is considered as one of the environmental problems in the world and especially developing countries. Also, after irregular growth of industries of country in the recent years, environmental pollution resulting of wastewater of industrial units is one of the most serious risks that continue of this process in increase of discharge of it to environment, press more stress to ecosystems and in other words to biodiversity (1). One of the usual methods in analysis of qualitative data of water that apply for obtaining of information and widely use for assessment of water quality characteristics is cluster analysis method that results of it helps to interpretation of information (2). This method includes two principal types: hierachical cluster analysis and partitioning method. In hierachical cluster analysis results illustrated through a cluster chart. It is considered as the easiest and most appropriate way in analysis of a small amount of accumulated data (3). A study by Wang,(2002) in Daya bay can be mentioned as one of the many studies which used cluster analysis in water quality investigation. In this research cluster analysis was used in grouping similar stations considering the amount of studied parameters based on which the stations were divided into three different categories (4). Also in Iran Moondanizadeh (2007) performed a research on the inorganic nitrogen compounds in the ground water of

Zeydoun plain with the use of cluster analysis method that obtained results indicated 19 points of sampling with a view to amount of inorganic nitrogen compounds divided to seven different groups (5). Also the aim of the present study was to determine the methodology of cluster analysis application in design of monitoring program and water quality management in Ahvaz pipe mills company. Monitoring is always the important part and the missing link in water management and wastewater control. Monitoring means providing information for controlling the input water, wastewater treatment and the final discharge (6). It's worth mentioning that establishing a monitoring system in industries leads to a better control of pollutant parameters. As a result, it will affect controlling and decreasing pollution load of output wastewater industries.

## MATERIALS AND METHODS

Ahvaz pipe mills company is placed in south area of Iran with an area about 130 ha in Karoun industrial zone in south eastern part of Ahvaz. This company has three steel pipes production plants with 6 to 56 inch diameters and two coating plants. For performing the present research first library and internet studies were done and the needed materials were collected. Then based on the position of each individual plant and workshop in Ahvaz pipe mills company their wastewater output was considered as a station. Also two stations were selected to investigate the civic water and the water entered the company, the last two stations were the input and output of the treatment plant that the input station was selected to observe the total pollution resultant of company and the output station to compare with the wastewaters output standard. In total 22 stations selected and specified the position of each station (See figure 1).

For investigating wastewater quality, 14 parameters including of T, Turb, pH, oil & grease, TSS, TDS, $BOD_5$, COD, EC, $Cl^-$, $Cl_2$, $Ca^{+2}$,$SO_3^{-2}$ and $SO_4^{-2}$ were selected. The sampling period took two months and was performed two times. After fixing, samples were transferred to the lab and measured based on lab methods of the book of standard methods (7). After obtaining the lab data, first the amounts of parameters were compared with wastewaters output standard and then MINITAB 14 software and cluster analysis test were used to compare the stations with a view to parameters and also to design a monitoring system.

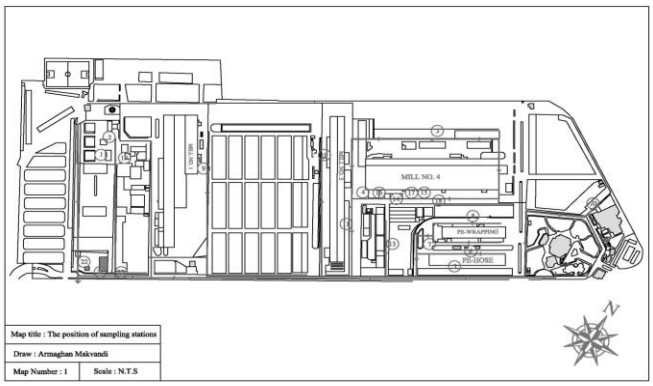


Figure 1. The position of sampling station

## RESULTS AND DISCUSSION

### *Results*

The output wastewater of Ahvaz pipe mills company in the present research was compared to the national standards of wastewaters discharge of Iran department of environment (See table 1).

Table 1. Average comparison of surveyed parameters in wastewater with national standard of wastewaters discharge in total time of sampling

| Parameter | | *National Standard of Discharge to Surface Water | In Compari-son with Standard | Amount of Measured Parameter in Wastewater (Average of Two Samples) | In Compari-son with Standard |
|---|---|---|---|---|---|
| T | $^0C$ | (Waver 3) | 1 | 26 | - |
| pH | - | 6.5-8.5 | 1 | 7.15 | 0.95 |
| Turb | NTU | 50 | 1 | 50 | 1 |
| TSS | mg/l | 40 | 1 | 46.5 | 1.16 |
| TDS | " | (Waver 1) | 1 | 2403 | - |
| $BOD_5$ | " | 30 | 1 | 108 | 3.6 |
| COD | " | 60 | 1 | 225 | 3.75 |
| Oil & Grease | " | 10 | 1 | 9.5 | 0.95 |
| $SO_3^{-2}$ | " | 1 | 1 | 8 | 8 |
| $SO_4^{-2}$ | " | 400(Waver 1) | 1 | 380 | 0.95 |
| $Cl^-$ | " | 600(Waver 1) | 1 | 912 | 1.52 |
| $Cl_2$ | " | 1 | 1 | 0.55 | 0.55 |
| $Ca^{+2}$ | " | 75 | 1 | 121 | 1.61 |
| EC | $\mu mho/cm$ | - | 1 | 3600 | - |

* Reference : Iran Department of Environment (1994)

Cluster analysis of the sampling stations with a view to each parameters separately was done in total time of sampling that obtained results are shown in table 2. The two parameters of T and COD were more noticeable in this section, therefore, these two are subsequently being explained.

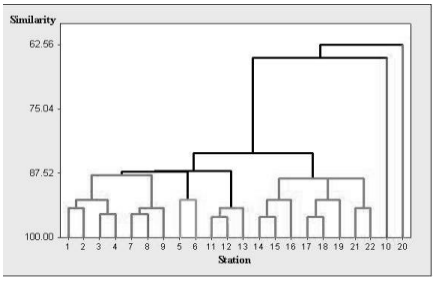


Chart 1. Cluster chart of similarity of stations with a view to amount of Temperature parameter in sampling period

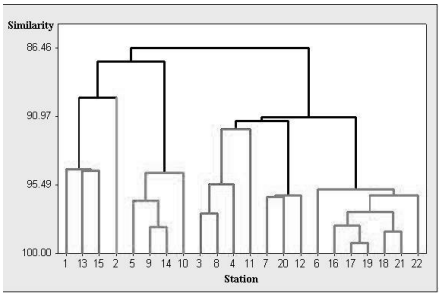


Chart 2. Cluster chart of similarity of stations with a view to amount of COD parameter in sampling period

According to obtained results of resultant cluster chart of cluster analysis test all along the sampling period (See chart 1), the 22 sampling stations based on their T parameter were classified to 6 different groups, in which each member had its own characteristics. The classification was as follows: first group: stations 1, 2, 3, 4, 7, 8 and 9, second group: stations 5 and 6, third group: station 10, fourth group: stations 11, 12 and 13, fifth group: stations 14, 15, 16, 17, 18, 19, 21 and 22 and six group station 20. As see in cluster chart as to classification of stations with a

view to similarity in amount of T parameter, the most stations placed in group five and then in group one and each of groups three and six have only one station. Also according to obtained results of resultant cluster chart of cluster analysis test all along the sampling period (See chart 2), the 22 sampling stations considering the amount of similarity in COD parameter were divided into 6 different groups. The classification was as follows: stations 1, 13 and in the first group, station 2 in the second group, stations 3, 4, 8 and 11 in the third group, stations 5, 9, 10 and 14 in the fourth group, stations 6, 16, 17, 18, 19, 21 and 22 in the fifth group and finally stations 7, 12 and 20 in the sixth group. As it can be seen in the cluster chart based on the similarity of the COD amount, group five had the highest number of stations and group two had just one member.

Table 2. The comparison of resultant groups of cluster analysis with a view to sampling stations in total time of sampling (each parameter separately)

| Parameter / Group | T ($^0$C) | pH | Turb (NTU) | TSS (mg/l) | Oil & Grease (mg/l) | COD (mg/l) | $BOD_5$ (mg/l) | $Cl^-$ (mg/l) | $^*Cl_2$ (mg/l) | EC (mg/l) | TDS (mg/l) | $Ca^{+2}$ (mg/l) | $SO_3^{-2}$ (mg/l) | $SO_4^{-2}$ (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1, 2, 3, 4, 7, 8, 9 | 1 | 1, 2, 3, 5, 6, 7, 8, 9, 13, 14, 15 ,16 | 1, 2 | 1, 2 | 1, 13, 15 | 1, 2 | 1,10 | 1 | 1, 4, 8, 13 | 1, 4, 8, 13 | 1 | 1, 2 | 1, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22 |
| 2 | 5, 6 | 2, 3, 4, 5, 6 | 4 | 3, 6, 7, 13, 15, 22 | 3, 4, 5, 6, 7, 8, 9, 10, 13, 15, 19, 20, 22 | 2 | 3, 4, 7, 8, 11, 12, 14, 16, 17, 18, 19, 20, 21, 22 | 2 | 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 | 2 | 2 | 2, 7 | 3 | 2 |
| 3 | 10 | 7 | 10 | 4, 5, 8, 9, 10, 14, 16, 17, 18, 20, 21 | 11 | 3, 4, 8, 11 | 5, 9 | 3 | 21 | 3 | 3 | 3, 19 | 4, 5, 6, 7, 8 | 3 |

The rest of table 2 – The comparison of resultant groups of cluster analysis with a view to sampling stations in total time of sampling (each parameter separately)

| Parameter / Group | T ($^0$C) | pH | Turb (NTU) | TSS (mg/l) | Oil & Grease (mg/l) | COD (mg/l) | $BOD_5$ (mg/l) | $Cl^-$ (mg/l) | $^*Cl_2$ (mg/l) | EC (mg/l) | TDS (mg/l) | $Ca^{+2}$ (mg/l) | $SO_3^{-2}$ (mg/l) | $SO_4^{-2}$ (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 11, 12, 13 | 8, 9 | 11 | 11 | 12 | 5, 9, 10, 14 | 6 | 4, 7, 8, 9, 13, 15 | 22 | 5, 6, 7, 9, 11, 12, 14, 15, 16, 17, 18, 20, 21, 22 | 5, 6, 7, 9, 11, 12, 14, 15, 16, 17, 18, 20, 21, 22 | 4, 5, 6, 8, 9, 13, 14, 15, 16, 17, 18, 21, 22 | 9, 11, 12, 13, 14, 15, 16, 17 | 10 |
| 5 | 14, 15, 16, 17, 18, 19, 21, 22 | 10 | 12 | 12 | 14, 16, 17, 18 | 6, 16, 17, 18, 19, 21, 22 | 10, 13 | 5, 6, 11, 12, 14, 16, 17, 18, 20 | - | 10 | 10 | 10 | 10 | 11 |
| 6 | 20 | 11, 12, | 21 | 19 | 21 | 7, 12, 20 | 15 | 19, 21, 22 | - | 19 | 19 | 11, 12, 20 | 18, 19, | 19 |

| | |
|---|---|
| 13,<br>14,<br>15,<br>16,<br>17,<br>18,<br>19,<br>20,<br>21,<br>22 | 20,<br>21, 22 |

* Only $Cl_2$ divided to 4 groups causes to similarity of stations.

To determine the final monitoring stations with the purpose of designing a monitoring system, the average of the sampling results in May and June was calculated. Then average data was calculated with the help of cluster analysis test. According to obtained results of resultant cluster chart of cluster analysis all along the sampling period (See chart 3), the 22 sampling stations based on the similarity of the studied parameters were divided into 7 different groups in which each station was similar with to the other group mates but different from other group members.

The classification were as follows: stations 1, 8 and 13 in group one, station 2 in group two, station 3 in group three and station 4 in group four, stations 5, 6, 7, 9, 11, 12, 14, 15, 16, 17, 18, 20, 21 and 22 stations in group five, station 10 in group six and finally station 19 in group seven.

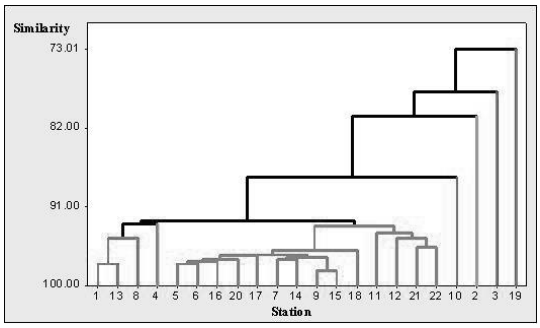


Chart 3. Cluster chart of similarity of stations with a view to amount of studied parameters in total time of sampling

As it can be noticed, the fifth group had the highest number and groups two, three, four, six and seven had just one station each. Hence, for determination the monitoring stations with the purpose of measuring the understudy parameters, stations can be chosen as follows: one of the stations of group five (Station number 11), group one (Station number 8) and also stations of groups two (Station number 2), three (Station number 3), four (Station number 4), six (Station number 10) and seven (Station number 19) (See fig. 2).

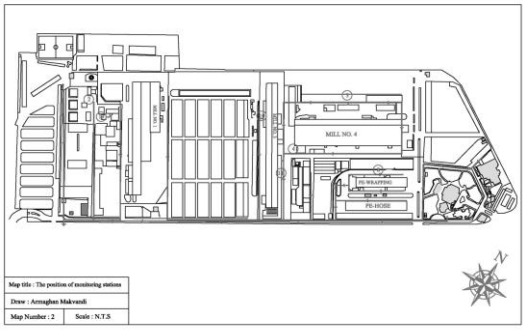

Figure 2- The position of monitoring stations

### *1-3- Suggested timing program for sampling of monitoring system*

Considering the pollutant source, measured parameters, objectives and importance of the project and sampling facilities, different sampling method can be selected. After selecting final monitoring stations, parameters and suggested timing for sampling of the monitoring system were determined. Parameters were divided into three categories of daily, weekly and monthly timing sampling (See table 3).

Table 3. Timing program of monitoring, sampling and measurement of output wastewater quality

| Parameter | | Repetition time of each measurement | | |
|---|---|---|---|---|
| | | Daily | Weekly | Monthly |
| T | $^0C$ | ❖ | | |
| pH | - | ❖ | | |
| Turb | NTU | ❖ | | |
| TSS | mg/l | | ❖ | |
| TDS | ” | | ❖ | |
| $BOD_5$ | ” | | ❖ | |
| COD | ” | | ❖ | |
| Oil & Grease | ” | | | ❖ |
| $SO_3^{-2}$ | ” | | | ❖ |
| $SO_4^{-2}$ | ” | | | ❖ |
| $Cl^-$ | ” | | ❖ | |
| $Cl_2$ | ” | ❖ | | |
| $Ca^{+2}$ | ” | | | ❖ |
| EC | $\mu mho/cm$ | ❖ | | |

### *Discussion*

Comparing the average of the investigated parameters in wastewater with the national standard of wastewaters discharge all along the sampling period revealed that the amount of TSS, $BOD_5$, COD, $SO_3^{-2}$, $Cl^-$ and $Ca^{+2}$ parameters are above the standard limits. A similar study on Tokyo metal industries indicated that the wastewater discharge of different units has high amount of $BOD_5$, oil and grease and TDS (8). In another research on Tehran province industrial wastewater indicated that the amount of Turb, pH, COD and TSS are also above the standard limits (9). A research on Foulad mobarakeh company indicated that the amount of $BOD_5$, COD, Cd, Pb and Zn are lower than the environmental standards (10). The results of the wastewater pollution of Ahvaz metal big industries indicated that the highest amount of pollution load of oil and grease and TSS parameters is by steel national group and also COD, $Cl^-$ and nitrate are produced by Ahvaz steel industries company. Comparing the results of the density of oil and grease, COD, TSS and $Cl^-$ parameters with environmental standards indicated that the obtained results are higher than the permissive limits (11). Investigation on the amount of oil and grease, TSS and COD parameters in Khouzestan steel company indicated that they declined to under permissive limits of standard output (12).

All along the sampling none of the 6 resultant groups of cluster analysis showed any similarity, but in the first group of station 1. Based on the obtained results of cluster analysis test, sampling stations of each separate group were similar to each other, but they showed a little similarity in T and COD parameters. In this study cluster analysis test was performed and the stations were divided into seven different groups, finally one station of each group was chosen as the monitoring station which were stations 2, 3, 4, 8, 10, 11 and 19. The study revealed that cluster analysis test is an efficient method for monitoring stations selection. After designing the monitoring system, the under studied parameters were divided into three timing sampling: daily, weekly and monthly. Considering the company process of work, parameters of group one including T, pH, Turb, $Cl_2$ and EC were selected as parameters with suggested timing of daily sampling. In group two TSS, TDS, $BOD_5$, COD and $Cl^-$ parameters were selected for the weekly purposes. Also in group three oil and grease, $SO_3^{-2}$, $SO_4^{-2}$ and $Ca^{+2}$ were chosen for the monthly purposes.

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