2010 International Conference on Biology, Environment and Chemistry
IPCBEE vol.1 (2011) © (2011) IACSIT Press, Singapore

Study on the Characteristics of Quality of Wastewater in Highway Tunnel Construction

Liu shan
Chang'an University
Xi'an， Shaanxi
liushanchd@163.com

Xu feng, Liu ping, Gui haoyao
Chang'an University
Xi'an，Shaanxi
superme1334@163.com

Abstract—**Through the testing and analysis of contaminants in wastewater before and after blasting in highway tunnel construction, it has been found that the major overproof indexes are its pH and SS, besides some tiny amount of toxic substances. Tests show that this type of wastewater has a phenomenon of self purification, which comes from the use of shot concrete. This phenomenon was further verified in experiments. Hence the research is helpful for the study on the treatment techniques of wastewater in tunneling.**

Keywords:Tunnel;blasting;construction; wastewater; toxic substances

Drilling and blasting method is often used in highway tunnel construction in mountainous terrains. The method involves the use of different dynamites under different geological conditions, and ammonium nitrate explosives with low toxicity are generally used[1,2]. After a blasting, the contaminants in the resulting water are mainly suspended substance (SS), chemical oxygen demand (CODcr), ammonian (NH_3-N), total phosphorus(TP) and oils[3-4], in addition to residual substances of dynamites such as 2,4,6-trinitrotoluene and nitrobenzene. Though some literatures in China have discussed the characteristics of wastewater in tunneling and its detrimental effect on environment[4,5], research on the difference in water quality before and after a blasting can hardly be found. Through the gathering and analysis of data concerning the quality of wastewater before and after blasting on two highway tunnel construction sites, and in combination with the corresponding research results in China, this paper, therefore, conducted some study on this issue to some extent.

I. Sources and Characteristics of Impact of Wastewater in Tunneling

Wastewater in tunneling mainly consists of muddy water resulting from excavation, drilling, construction of continuous protecting wall and use of shields, water for eliminating dust after blasting, water seeping out of shot concrete, discharged water from mixing plants, etc.. Where a tunnel encounter adverse geological conditions, muddy water-gushing out of rocks and fissure water and so on are also the major sources of wastewater[6,7].

Most dynamites adopted in tunneling are of emulsified ammonpulver, whose products after blasting not only make concentration of nitrates in nearby water bodies beyond the limits, but also contain toxic materials such as NO_2^-. Emulsifiers in the dynamites are of oil in most cases, with water-gushing into the surface water body, they usually make it polluted. In addition, the residual substance of the dynamite mainly consists of trinitrotoluene and nitrobenzene with high toxicity, which would poison human being and animals if entering a water body.

II. Survey and Analysis of Wastewater in Highway Tunneling

A. General description of experimental tunnel

Two highway tunnels have been investigated in the study, i.e., one is Baojia Mountain Tunnel，another is Zhouhebei Highway Tunnel.

The first tunnel is located on the ridge of south Qinling Mountain, with the tallest peak as high as 1360m above sea level. It is 11.2km long, penetrating through two peaks (Qing Mountain and Yuhuan Mountain), with a maximum depth of 660m below the ground surface. Within the tunneling zone, there are complicated geological formations, well-developed faults and drapes, and the surrounding rocks are mainly of phyllite, limestone and slate. There is rich underground water, with spring water gushing out occasionally, giving rise to an inflow of water in a range of $13.54m^3/h$ ~$103.25m^3/h$.

The second tunnel project consists of two tunnels, No.1 tunnel and No.2 tunnel, with a length of 121m and 479m respectively. The tunneling zone is characterized by its tectonic formations of eroded moderate to low mountains, with quartz schist as its major surrounding rocks. Except for sections at the entrance and exit where the rocks are shallowly buried, most of the tunnels are 20m-120m under ground. The tunnels are located on the transitional zone of an anticline. On the tunnel site are thick weathered layers of rocks, well developed fissures and joints and rocks with high permeability, resulting in a low inflow of water in a range of $8.9m^3/h$ ~$9.4m^3/h$.

B. Investigation of quality of water in highway tunneling

Sampling of wastewater was conducted from September to October in 2006, with samples taken before and after blasting. Major factors in analysis included pH, CODcr, SS, NO_3^-, oil and nitrobenzene. Detected pH of the test in the field, samples of CODcr, SS, NO^{3-}, oil and nitrobenzene were tested after being transported to the environmental monitoring center, with sampling and transportation in accordance with the provisions in Standard Methods for the Examination of Water and Wastewater(4th version) issued by Environmental Protection Bureau of China.

Sampling spots for Baojia Mountain Tunnel was located at the outlet of its exit and collection sumps in the blasting zones, and the qualities of wastewater after testing are listed in Table 2.1, where there is neither oil nor nitrobenzene since they were not found either before or after blasting.

For Zhouhebei Tunnel, the sampling spots were located at the operation zone of No.2 tunnel since it is the longer one. Samples were taken from the collection sumps at two cross sections in the blasting area, with the test results listed in Table 2.2, where nitrobenzene was indicated as "not found".

Table 2.1 and Table 2.2 indicate:

1) Wastewater in tunneling is alkaline in common;

2) Qualities of wastewater from different tunnels vary considerably, which depends on the richness of water;

3) After a blasting, nitrate, CODcr and SS all increase;

4) Because of the air drilling before blasting produced large amount of small pieces of rocky materials, and disturbed suspended matters that had deposited, SS increased after blasting;

5) There is a great change in oily substances due to the oil leakage of mechanical equipment;

6) Nitrobenzene was not found in testing.

It has been found from the analysis of specimens of wastewater in highway tunneling that after having been left for some time without disturbance, the wastewater will have a lower concentration of pollutants. This shows that such wastewater has a certain characteristics of self-purification, which can be proved to be from the coagulating effect of cement paste of shot concrete in protection work.

III. Analysis of Sedimentation of Wastewater in Tunneling

A. *Sedimentation test*

On the basis of the phenomenon that after having not been disturbed for some time, wastewater in tunneling will have a lower concentration of pollutants, the simulation test for the analysis of treatment effect has been conducted.

Wastewater specimens were manually prepared with clay, oil and nitrobenzene, each in a range of 100~200mg/L, 50~100mg/L and 5-20mg/L respectively. By using cement, common coagulants such as aluminum sulfate, ferrous sulfate and ferric trichloride to conduct the test respectively, and under their optimal concentrations, comparison of the treatment effect of cement and common coagulants are as listed in Table 3.1.

From Table 3.1, it is clear that common coagulants have no marked advantage over cement. Though the removal effect of cement on CODcr is inferior to that of aluminum sulfate, it is superior to ferrous sulfate and ferric trichloride; The removal rate of nitrobenzene with cement is lower than with aluminum sulfate, ferrous sulfate or ferric chloride; the removal rate of oil with cement is less than that with aluminum sulfate or ferric trichloride, but higher than with ferrous sulfate. Parameter total description, cement has fairly good effect of flocculation. After sedimentation, cemented blocks will be produced, they can be treated by burying together with waste soil in a spoil ground.

B. *Lixiviation test*

For precipitated concrete blocks with wastewater in tunneling, lixiviation test was conducted.

For manually prepared specimens of wastewater with clay, oil and nitrobenzene, cement was added, with the mixture undisturbed for 12 hours to form cemented clocks, which was then immersed in distilled water. After certain time, clear water on the top was taken for the measurement of concentration of CODcr, oil and nitrobenzene, and the test results are plotted as shown in Fig. 3.1, which shows that the concentrations are stable and nitrobenzene has not been found.

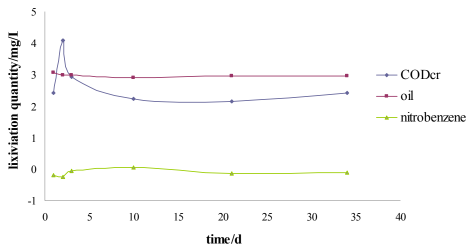

Fig3.1 result of lixiviation text(time:day)

IV. Analysis of Quality Characteristics of Wastewater in Highway Tunneling

With reference to the current Quality Standards for Surface Water Ambient Quality Standard GS and Integrated Wastewater Discharge Standard in China, the test results show that measured SS values for the two tunnel project are respectively 0.3~2.7 and 1~2.7 times the class III thresholds in Quality Standards for Surface Water Resources (SL63-94), with each maximum measured value greater than the limit for class I standard in Integrated Wastewater Discharge Standard. Test result of CODcr indicates that for both tunnel projects, CODcr values are lower than the limit stipulated in Integrated Wastewater Discharge Standard, so that the wastewater can hardly cause the problem of environmental pollution. The measured value of oil for Zhouhebei Tunnel shows that the concentration of oil in wastewater is equal to the limited standard value, with the maximum value 10.2. For both projects, the pH value is 13~14, which is much higher than the corresponding limit for surface water.

It is obvious from above that the cement mortar adopted for a protective work in tunneling has certain flocculating effect on wastewater. After treatment by sedimentation, toxic substances in wastewater in tunneling can be removed effectively. It is possible, therefore, to use cement jointly with other common coagulants to treat wastewater so as to reduce the dosage of the latter.

Wastewater in tunneling is alkaline in nature, this is because after hydration the major compositions of cement mortar produce tricalcium silicate, dicalcium silicate and calcium hydroxide, all of which are alkaline, and will cause higher pH after they are dissolved in water. After treatment with cement, the pH of wastewater in tunneling needs to be further treated before being discharged into natural water bodies.

The key polluting indexes of wastewater in tunneling are, therefore, its suspended substances and pH.

V. CONCLUSIONS

From field investigation and experimental analysis, it is clear that there is a large undulation in the quality of wastewater in tunneling, depending on the abundance of water (with smaller concentration corresponding to higher water quantity); after a blasting, nitrate, CODcr, SS and toxic substances in the wastewater all increases, but cement mortar for grouting or shotcrete both has some coagulating effect on the wastewater, and can lower the concentration of pollutants after sedimentation; the large variation in petroleum oil is caused by the accidental leakage of oil from construction equipment, which can be reduced with good maintenance; and the major overproof indexes of wastewater in tunneling are its pH and SS.

[1] Li-Naixia. Study of The Impact on The Water Environment during The Constryct of The Gelesham Railway Tunnel, Southwest Jiaotong University, Master Degree Thesis,2004.4

[2] LiuHuang. The Research of The Gelesham Tunnel Constructing Dregs's Impact on The Soil Environment, Southwest Jiaotong University, Master Degree Thesis,2004.5

[3] Ding Tinghua, Wang Shaotang, Song Xiujie, Yuan Wenying. The Research on Groundwater Pollution and Recovering of Water Quality around the Ming Tombs Power Station, Environmental Science, Vol.19 , No.3 , May. 1998

[4] Y ANG Bin, MO Ping, WU Dongguo. Analysis of Characters of Quality of Wastewater from Tunnel Construction, Technology of Highway and Transport, No.3 , Jun.. 2009

[5] Zheng Xinding, Ding Yuanjian. Analysis of the influence of tunnel construction wastewater on water environment and counter measures, Science & Technology of Baotou Steel (Group) Corporation, Vol. 44 , No.6 , Dec. 2007

[6] Yuan Yong.Construction and environmental protection of Geleshan tunnel[J], Modern mgTunnelling Technology, 2004,41(1):68-72

[7] Wei Xiankun. Countermeasures against environmental impact in the construction of Zhongnanshan extra-long tunnel[J], Modern Tunnelling Technology, 2003,40(6) : 31-38

TABLE 2.1 TEST RESULTS OF WASTEWATER IN THE CONSTRUCTION OF BIAOJIASHAN TUNNEL unit: mg/L

Sampling spot		**Result**					**Low rate**
		Nitrate	**CODcr**	**SS**	**Oil**	**Nitrobenzene**	
Outlet	Before blasting	26.04	18.1	10	Not found	Not found	$18.1m^3/h$
	After blasting	10.24	3.36	14	Not found	Not found	
sump	Before blasting	31.13	9.73	17	Not found	Not found	
	After blasting	50.68	20.6	81	Not found	Not found	

The wastewater has a pH value in a range of 9~13.

TABLE 2.2 TEST RESULTS OF WASTEWATER IN THE CONSTRUCTION OF BIAOJIASHAN TUNNEL unit: mg/L

Sampling spot			**Result**					**Flow rate**
			Nitrate	**CODcr**	**SS**	**Oil**	**Nitrobenzene**	
Section 1	specimen1	Before blasting	17.7	19	47	0.73	Not found	$9.0m^3/h$
		After blasting	18.0	20	33	0.57	Not found	
	specimen2	Before blasting	13.5	24	60	4.30	Not found	
		After blasting	14.1	58	34	0.51	Not found	
	specimen3	Before blasting	16.9	66	13	10.2	Not found	
		After blasting	16.4	47	45	8.67	Not found	
Section 2	4—before blasting		2.63	8	83	0.25	Not found	$8.0m^3/h$
	4—after blasting		13.8	22	29	0.33	Not found	

The wastewater has a pH value between 13 and 14.

TABLE 3.1 COMPARISON OF THE TREATMENT EFFECT OF CEMENT AND COMMON COAGULANTS

Index	**Removal rate of CODCr (%)**	**Removal rate of nitrobenzene (%)**	**Removal rate of oil (%)**
Cement	39.1	12.6	10.9
Aluminum sulfate	54.8	28.6	15.2
Ferrous sulfate	10.1	24.0	6.8
Ferric trichloride	10.2	21.2	11.6
Note：concentration before treatment(mg/L)	93.8	16.0	6.4