A Case Study on The Impact of The Leather Industries on The Ground Water Aquifer in Bangladesh

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***Abstract* — Leather industry plays an important role in Bangladeshi Economy due to its large potential for employment, growth and export. At the same time, it poses serious environmental threats by discharging liquid effluents and solid wastes directly into surrounding low lying areas without proper treatment. In a study of 2001, relatively high concentrations of Chromium, Lead and Sulfide was identified in the ground water in Hazaribagh area but in another study of 2008 there was no sign of any contamination. This paper describes a recent survey conducted in 2010 whose major objective was to monitor the water quality of selected DWASA deep tubewells of Hazaribagh area for the presence of contamination by tannery wastewater and to identify the trend of change of water quality. A high concentration of chemical oxygen demand (COD) (from 7.9 to 8.5 mg/l) was observed in the month of April in all wells of Hazaribagh. Sulfide concentrations in some of the samples were found to be excessively high, varying from 0.0-10.0 µg/l. Relatively higher concentration of iron (0.0 to 1.2 mg/l) and ammonia (0.0 to 1.272 mg/l) were detected in some water samples. EC concentration was higher for all the wells (300 µg/cm to 500 µg/cm). The groundwater resources at Hazaribagh area that have been sampled in this investigation mostly satisfy the WHO and Bangladesh drinking water standard for the parameters tested in the study. But some elevated levels of COD, sulfide and lead have been detected which may be a matter of concern.**

***Index Term* — Tannery effluent, water quality, absorption, contamination.**

I. Introduction

MAZARIBAGH is a densely populated area of Dhaka city where the main leather tanning industries of Bangladesh are situated. There are about 200 leather processing industries in Hazaribagh area. In a tannery, different operations require large volume of water for the purpose of washing in each step. The average volume of water required for the processing of one ton of hide is about 50 m^3 (WHO, 1982).Waste water from tannery industry contains chromium, dissolved lime, hydrogen sulfide, dyes, oils, organic matter and suspended solids. The industries are discharging their solid wastes and liquid effluents containing rotten flesh, fat, blood and skin, toxic chemicals etc. directly into low lying areas and water bodies without proper treatment. So, there is an obvious risk of percolation of leachate, which may affect the ground water quality. In the flood plain between the Buriganga River and Hazaribagh area, a dike was constructed in 1988. Between the dike and Hazaribagh area there are stagnant ponds. The tannery wastewater is discharged into the ponds without proper treatment. Finally this wastewater is discharged into Buriganga river.(Ganesh, Ali). The tannery wastewater retains in the stagnant ponds for prolonged periods of time. This allows the dissolved constituents from the wastewater to percolate into the subsurface. This can contaminate the precious groundwater resource. Thus water quality of the rivers deteriorates increasingly and these pose a significant threat to our limited water supply by changing taste and odor, growth of aquatic weeds, aquatic life and wild life.

In Hazaribagh area, groundwater is extracted through a network of 8 deep tube wells and distributed to the dwellers through distribution system. Any contamination of ground water would endanger not only the water supply network of this particular area but also the entire water supply system in Dhaka city. Groundwater samples were collected from 7 deep tubewells of DWASA Zone-2 (Hazaribagh area) and have been analyzed for a wide range of parameters including chromium, iron, lead, manganese, pH, chloride, sulfide, ammonia, COD and total dissolved solids. This study aims to analyze the present status of surface water pollution and a statistical comparison of the quality of water in different seasons at different locations of Hazaribagh area.

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II. Methodology

The area of Hazaribagh is situated in the south west side of Dhaka City. It is a densely populated area of Dhaka, where about 185 leather processing industries are located in a congested area of only 70 acres. The tannery industries are operating and discharging solid and liquid wastes directly to the low-lying areas, river and natural canals without proper treatment. Tanneries in the Hazaribagh area discharge some 21,600 cubic meters of liquid wastes every day. The contaminated low-lying land area is about 25 hectors and this zone is categorized as Red Zone according to Department of Environment (DoE), Bangladesh. Around 20,000 peoples are presently living in the slums in this area, under extremely densely populated and unhygienic conditions.

A. Study Area

There are about 40 deep tubewells in DWASA Zone 2. Among them 8 is located at Hazaribagh area. In this study, samples were collected from 7 stations.

TABLE I
DWASA ZONE-2 PUMP LOCATIONS

Well No.	Pump Location
1	Shishu Park Pump
2	BDR No.2 Pump (near BDR Gate No.1)
3	Hazaribagh -3 (near Phoenix Textile)
4	Hazaribagh -4 (Baddanagar Water Tank)
5	Hazaribagh -5 (near Leather Technology College)
6	Gajamahal Pump
7	Kalunagar Pump

B. Collection of Sample

Groundwater samples were collected from 7 DTW stations during the period of January 2010 to September 2010 covering dry and wet periods. To determine the extent of pollution of the surrounding rivers of Dhaka city, various water quality parameters were monitored and a detailed field survey has been conducted within the study area.

Sampling was conducted between 10 a.m. and 6 p.m. based on weather conditions. For collecting the samples, some fresh plastic containers were used. The capacity of the containers was 1 to 1.5 liters. At first, the water was allowed to flow freely from the source for a few minutes. Then the containers were washed three times with the pump water and then it was filled with that water. After filling it, the cap of the container was closed and sealed to prevent it from contamination. The container was filled fully so that no air bubble remains in the sample. After that, the containers were marked properly with waterproof level including all the information required by the laboratory. Bottles were protected from contamination during transport to and from the sampling site. Ammonia, Conductivity, pH and Sulfide were measured immediately. The rest of the samples were transferred to refrigerator as soon as possible to test the other parameters next day.

C. Analysis of Water Samples

The water samples collected from the 7 pump stations of DWASA Zone 2 were analyzed for pH, Chemical Oxygen Demand (COD), Ammonia, Sulfide, Electrical Conductivity (EC), Chromium, Lead, Iron, Chloride and Total Dissolved Solid (TDS). Temperature measurements were also carried out. pH of the water sample was measured using a pH meter (HACH). TDS and COD were determined by volumetric methods following Standard Methods. Iron concentration was determined using potassium permanganate agent. Iron concentration was measured using the thiocyanate cholorimetric method. Ammonia was determined using Nessler method. Conductivity was measured using a conductivity meter. Chloride concentration was identified using silver nitrate titremetric method. Chromium concentrations in the water samples were measured with an atomic absorption (flame) spectrophotometer (Shimadzu Corporation Model number AA 6800). Lead was also measured with the atomic absorption spectrophotometer.

III. Results and Discussions

The water samples collected from the 7 pump stations of DWASA Zone 2 were analyzed for pH, Chemical Oxygen Demand (COD), Ammonia, Sulfide, Electrical Conductivity (EC), Chromium, Lead, Iron, Chloride and Total Dissolved Solid (TDS). Temperature measurements were also carried out. pH of the water sample was measured using a pH meter (HACH). TDS and COD were determined by volumetric methods following Standard Methods. Iron concentration was determined using potassium permanganate agent. Iron concentration was measured using the thiocyanate cholorimetric method. Ammonia was determined using Nessler method. Conductivity was measured using a conductivity meter. Chloride concentration was identified using silver nitrate titremetric method. Chromium concentrations in the water samples were measured with an atomic absorption (flame) spectrophotometer (Shimadzu Corporation Model number AA 6800). Lead was also measured with the atomic absorption spectrophotometer.

A. Characteristics of Groundwater

The groundwater samples have pH within 6.20-7.49 which lies within the Standard limit of WHO and ECR'97. pH in water samples from 7 DTW pump stations were found to follow similar pattern during testing period. For all the well, maximum pH was recorded in the month of April while the minimum during September. In January pH of samples vary within a narrow range from7.00-7.49. During the months of February, April, May, July and September these ranges were 6.85-7.16, 7.18-7.67, 6.45-6.89, 6.57-7.10 and 6.20-6.38 respectively. pH values of Well 6 appear to be higher (averaging close to or below 7.50) compares to the six tube wells where average values varied from about 6.74-7.84. Electric conductivity (EC) of the collected sample follows a more or less common increasing trend from January to September. Samples of well 6 has got the lowest average EC (340 µS/cm) while highest average EC (486 µS/cm) was recorded for well no 2. Average EC of other well ranges from 364µS/cm to 423µS/cm. As expected, conductivity values followed the trend observed for TDS and chloride.

TABLE II
pH OF GROUNDWATER SAMPLE FROM DWTS OF DWASA, ZONE-2.

Month	Well No.1	Well No.2	Well No.3	Well No.4	Well No.5	Well No.6	Well No.7	BD Standard	WHO Standard
Jan	7.09	7.08	7.01	7.16	7.08	7.49	7.0	6.5-8.5	8.5
Feb	6.95	6.85	6.88	7.0	6.95	7.16	6.86	6.5-8.5	8.5
Apr	7.27	7.29	7.18	7.41	7.31	7.67	7.25	6.5-8.5	8.5
May	6.6	6.45	6.45	6.53	6.5	6.89	6.5	6.5-8.5	8.5
Jul	6.84	6.77	6.61	6.57	6.66	7.1	6.7	6.5-8.5	8.5
Sep	6.34	6.38	6.33	6.20	6.31	6.36	6.32	6.5-8.5	8.5

TABLE III
EC (µS/cm) OF GROUNDWATER SAMPLE FROM DTWS OF DWASA, ZONE-2.

Month	Well No.1	Well No.2	Well No.3	Well No.4	Well No.5	Well No.6	Well No.7
Jan	321	394	343	383	338	286	299
Feb	404	504	423	480	415	362	364
Apr	386	474	426	455	396	346	345
May	404	494	438	488	416	350	366
Jul	400	483	444	487	411	344	369
Sep	412	568	468	508	426	354	444

Total Dissolved Solids was recorded for the month of May, July and September only. TDS data shows a typical trend in all the observed well which is closely similar to that of chloride value. TDS values vary from 250mg/l to 420mg/l. TDS was also calculated from EC data by the standard relationship TDS (mg/l) = 0.67* TDS (µS/cm). Most of the results are very close to the analysis result except a few differs abruptly. Chemical oxygen demand of water samples satisfy the maximum limit of COD in drinking water except the samples collected in April. COD value of water samples vary from 1.3 mg/l to 2.8 mg/l for rest of the months whereas in April the value was found to be within 7.9 mg/l to 8.5 mg/l. since this value is abnormally high and found to be within normal range in the next month the COD value of April can be ignored. As the COD values are low ground water of the area can be considered to be free of organic load.

TABLE IV
TDS (mg/l) OF GROUNDWATER SAMPLE FROM DTWS OF DWASA, ZONE-2.

Month	Well No.1	Well No.2	Well No.3	Well No.4	Well No.5	Well No.6	Well No.7	BD Standard
May	274	309	275	315	280	260	260	0.3-1.0
Jul	250	286	291	308	234	248	248	0.3-1.0
Sep	305	331	344	420	324	257	257	0.3-1.0

Chloride concentration of water samples from 7 DTW pump stations were found to vary from 4mg/l to 54mg/l. All values satisfy the Bangladesh Standard as well as the WHO guideline value for drinking water. Since tannery waste contains high concentration of chloride, higher concentration of chloride was expected in the water samples. However although no clear well wise trend could be observed, chloride concentration of samples (averaging close to 7 mg/l) from well 6 are clearly lower than those of other wells. Chloride concentrations of water samples from other wells are relatively high, averaging from 32mg/l to 42 mg/l. Iron concentrations was found to be vary from 0.1mg/l- 1.2 mg/l. no common trend was observed in iron among the wells but in well 2 iron was detected only in three samples out of 6.one sample of well 6 exceeds the Bangladesh standard for drinking water while 3 samples of well 3 are very near to the standard limit.

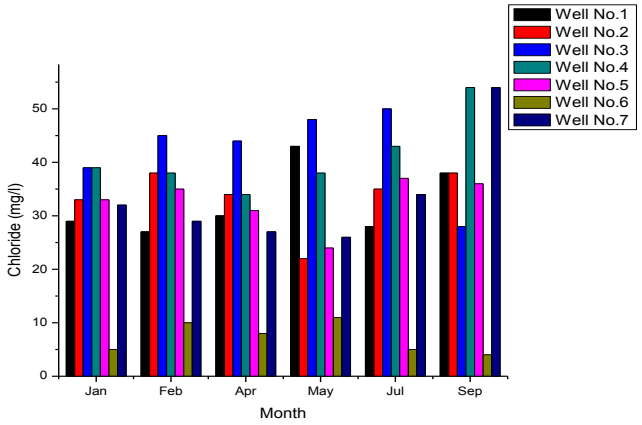

Fig. 1. Variation of Chloride concentration with observed months at different tube-wells

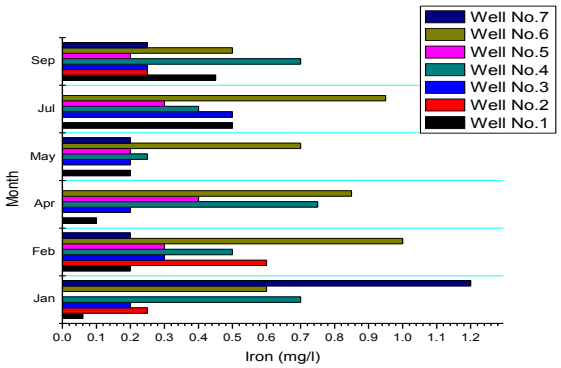

Fig. 2. Variation of Chloride concentration with observed months at different tube-wells

The concentration of sulfide in drinking water should be zero according to ECR and WHO guideline. But it was found from the test results that concentration of sulfide in 9 water sample exceeds the drinking water standard.

Significant amount of sulfide was detected randomly in almost all the wells once or twice except well no 5. However, as no other contaminants (like chloride) seem to have leached out high sulfide concentration could also be of natural origin. Ammonia has been detected in samples from all well. Although no clear trend could be observed, ammonia of water samples of well 4 and well 6 are marginally higher than those of other wells .in fact one water sample from well 6 and one from well 4 exceeded the standard for Bangladesh drinking water. The lowest concentration was recorded 0.12 mg/l (well no 1) which is higher than the detection limit 0.017mg/l.

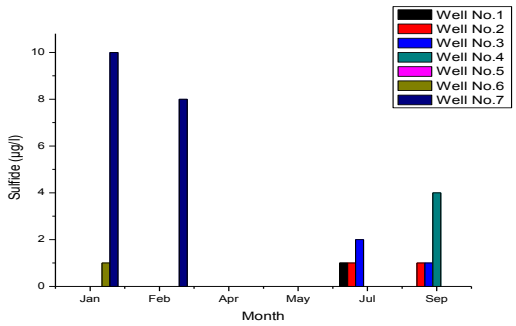

Fig. 3. Variation of Sulfide concentration with observed months at different tube-wells

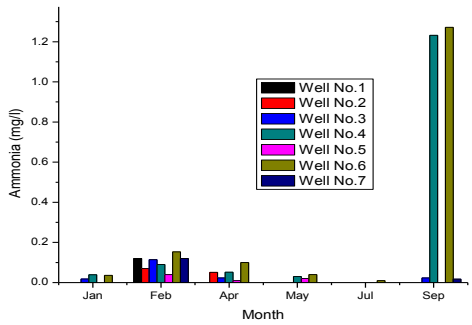

Fig. 4. Variation of Ammonia concentration with observed months at different tube-wells

Lead concentrations in water samples from 7 DTW pump stations were found to vary from 0.004mg/l to 0.041 mg/l. lead has been detected in every sample. All satisfy the Bangladesh standard as well as the WHO guideline value for drinking water. For heavy metal analysis sample should be acidified during collection which was not done here. This may affect the result since heavy metal tends to accumulate on the wall of the container. Chromium concentration (vary from 0.001mg/l to 0.005mg/l) in none of the water samples exceeded the Bangladesh standards as well as WHO standard.

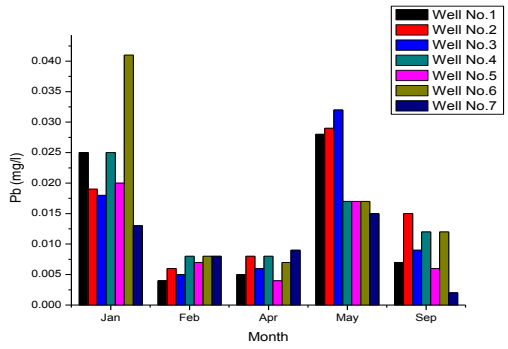

Fig. 5. Variation of Lead concentration with observed months at different tube-wells

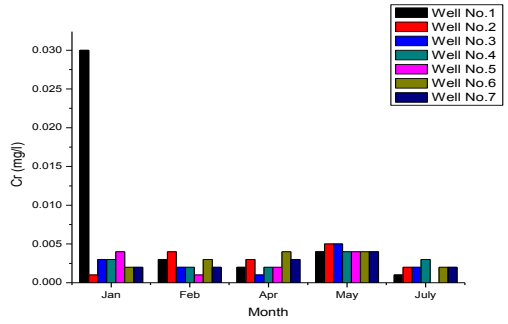

Fig. 6. Variation of Chromium concentration with observed months at different tube-wells

B. Comparison with Previous Results

Available previous groundwater quality data of Hazaribagh area were reviewed and summarized for any evidence of trends occurring within the last 10 years. The review included the water quality data of DTW pump station collected by Saha (2001) and data from EU-ASIA ECO PROGRAMME interim report (2008). Some limited data of DWASA (2006) was also evaluated.

pH of Well No 1 varied from 6.34-7.27 in 2010 which was 6.6 and 6.94 in the year of 2000 and 2008 respectively. For rest of the wells pH seems to vary within normal range for the last ten years. Electric Conductivity (EC) seems to increase as the value of EC was 194µS/cm-281µS/cm in 2000 while in 2010 EC of water samples were recorded 321- 568µS/cm. Since water samples in different year were not collected at the same season this variation may be due to seasonal change.

Total Dissolved Solids of the selected wells varied from 291mg/l-359mg/l in 2000. In 2006 During 2010 TDS value ranges from 250mg/l-420 mg/l. the lowest TDS was observed in water samples of well no 1 in both 2000 and 2010.

Most of the parameters vary within a small range except chromium concentration. Study by Saha (2001) found significantly higher chromium concentration (0.002mg/l-0.12mg/l) in the groundwater of Hazaribagh area. Water samples were collected in two phase. Chromium concentration in all water samples collected in June 2001 was lower than those in water sample collected in March 2000. But during 2006-2007 no Cr was found in the deep tube wells of Hazaribagh area as all values were below detection limit of 0.007 mg/l (EU-ASIA ECO PROGRAMME interim report, 2008). Present analysis shows that chromium is present in the groundwater at an acceptable limit.

The study has been focused to identify the present status of the groundwater quality of Hazaribagh area. Water samples were analyzed for detailed characterization. The analysis results indicate that the groundwater resources at Hazaribagh area that have been sampled in this investigation mostly satisfy the WHO and Bangladesh drinking water standard for the parameters tested in the study. But some elevated levels of COD, sulfide and lead have been detected which may be a matter of concern.

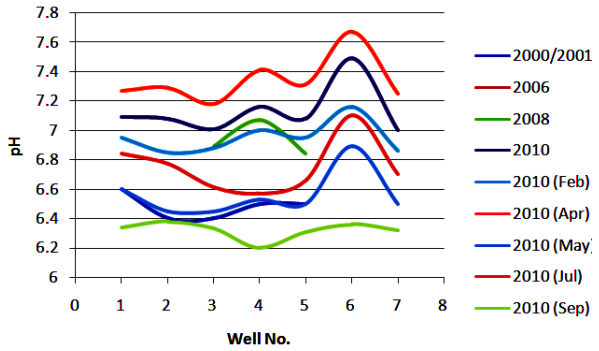

Fig. 7. Variation of pH in different years

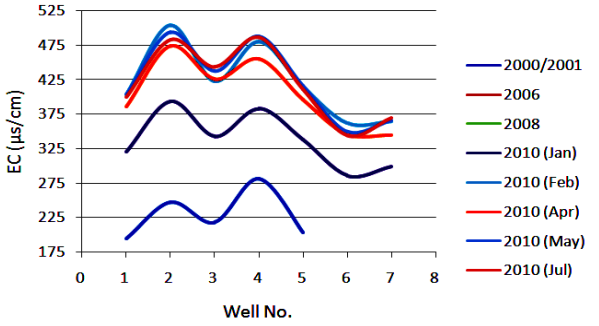

Fig. 8. Variations of EC (µs/cm) in different years

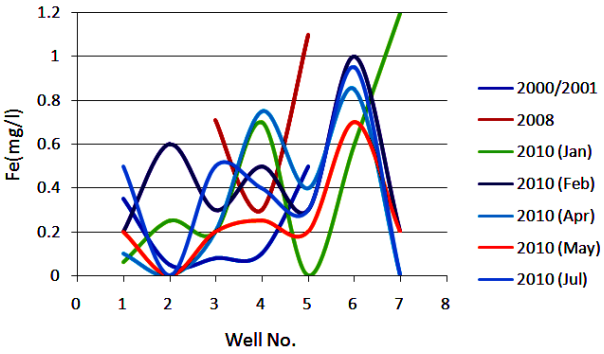

Fig. 9. Variations of Fe (mg/l) in different years

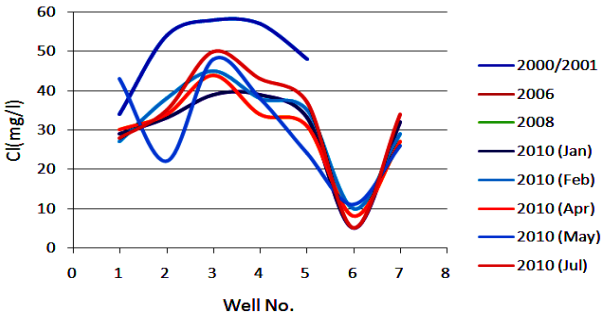

Fig. 10. Variation of Cl (mg/l) in different years

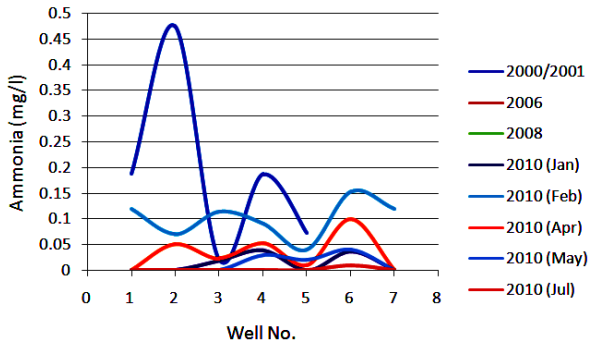

Fig. 11. Variations of NH_3 (mg/l) in different years

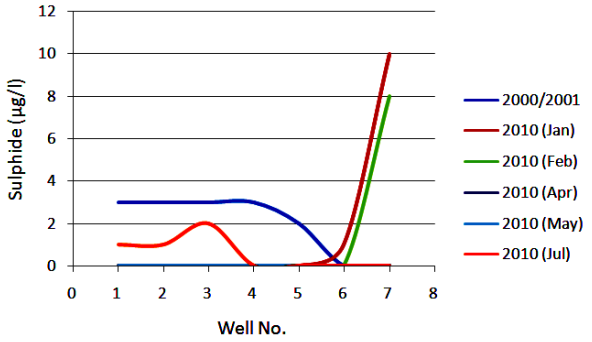

Fig. 12. Variations of Sulfide (µg/l) in different years

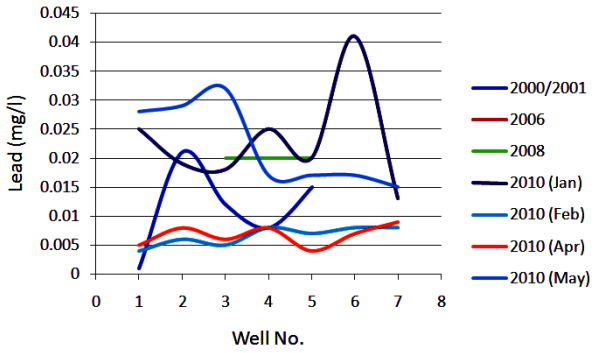

Fig. 13. Variations of Pb (mg/l) in different years

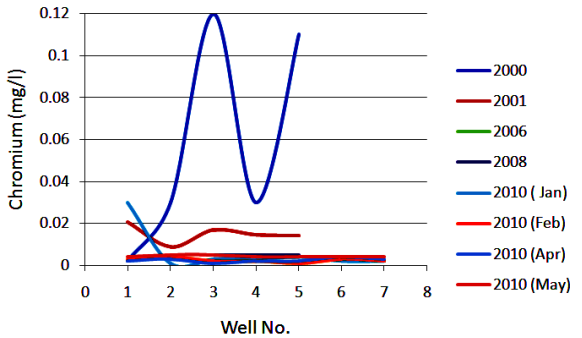

Fig. 14. Variations of Cr(mg/l) in different years

IV. CONCLUSION

The major objective was to monitor the water quality of selected DWASA deep tubewells of Hazaribagh area for the presence of contamination by tannery wastewater and to compare the present water quality of the tubewells with previous results. In order to assess the quality of groundwater, samples from 7 deep tubewells pump stations of DWASA Zone 2 (located in Hazaribagh area) were collected and analyzed. Some major conclusions have been derived from the analysis.

pH followed a common trend. None of the values exceeded the Standard limit. The maximum pH value was observed in April but the value decreased in May. The minimum value was found in the month of September for all the wells. The parameters were also monitored in 2001, 2006 and 2008. Ten parameters were measured in 2010. Among them Ammonia and Sulfide changed abruptly. These two parameters did not follow any common trend. High value of Ammonia was found in the month of September in two wells. In all wells Sulfide exceeded the Standard value in some of the time which indicates the contamination of the water.

COD values for all the wells were within the range except for the month of April. In April the value exceeded the Standard limit. The change of the value of Iron was very random. No similarity of Iron values has been found in the wells. The variation of Iron was different for different wells and did not follow a common trend. Alarmingly high Chromium and Lead concentrations were detected in 2000. But in our investigation, concentration of lead of only one sample was very close to the standard value set by WHO. Chromium concentration of all sample are bellow the standard limit.

Sometimes the water gets polluted a due to various reasons and mainly due to inflow of sewage into the source. Because of the contamination, the parameters of pure drinking water can be changed. This water can be a great threat to ecosystem though some parameters may not in the deteriorate level but the tannery wastes may cause all kind of water pollution in the near future.

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