Effect of heavy metals in wastewater effluents of Textile factory-Hilla on the characteristics of Hilla River

تأثير المعادن الثقيلة الموجودة في مطروحات معمل نسيج الحلة على خصائص نـهر الحلة

Research in environmental engineering

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Abstract:

The research includes monitoring and assessment on industrial pollution level in Hilla River under the effect of some major toxic heavy metals in Hilla textile factory effluent. The concentrations of selected toxic heavy metals, chromium (Cr) and lead (Pb), were determined for selective locations on the river. The monitoring period in this study were accomplished during periods of time six months represent and contain the predominating weather conditions in Iraq, the time of study starting from the dry and hot weather conditions in August / 2011 to the wet and cold weather conditions in January / 2012. The sampling through monitoring period was conducted from the middle of the river, starting in front of the outfall of Hilla textile factory to a distance 450 m downstream of the textile factory outfall. The assessment of Hilla River pollution with Cr and Pb show that the levels of Cr and Pb concentrations values through various weather conditions are compatible with its levels in several countries, where the Cr concentrations in Hilla River are within its acceptable limits in rivers and potable water, while the Pb concentrations in Hilla River exceed the permissible limits in rivers and potable water. Also, the Hilla textile factory effluent effects on the distribution of heavy metals concentrations with the distance along the river downstream the effluent outfall by a gradually increasing in the concentrations of heavy metals that is found in the effluent.

ألخلاصه:

يَتضمّنُ البحثُ مراقبة وتقييمَ على مستوى التلوثِ الصناعيِ في نهرِ ألحله الناتج من تأثيرِ بعض المعادنِ الثقيلةِ السامّةِ الرئيسيةِ في مطروحات معمل نسيج ألحله. تراكيز المعادنِ الثقيلةِ السامةِ المختارة، معدن كروم (Cr) والرصاص (Pb)، أوجدت لمواقع مختارة على النهر، تمت الدراسة خلال فترات زمنيه تمثّل وتحوي الظروف الجوية السائدة في العراق ابتدءا من الظروف الجوية الجافة الحارة خلال شهر آب / 2010 إلى الظروف الجوية الرطبة الباردة خلال شهر كانون الثاني / 2011. تم أخذ العينات خلال فترة المراقبة من منتصفِ النهر، بَدْءا أمام مصبِّ مطروحات معمل نسيج ألحله إلى مسافة 450 متر مِنْ مصبِّ مطروحات معمل نسيج ألحله. اظهر تقييمَ التلوثِ في نهر ألحله بمعدنِ Cr وPb أن مستويات تراكيز Cr و Pb خلال الظروف الجويةِ المُخْتَلِفةِ متوافقة مع مستوياتها في عِدّة بلدان، حيث تراكيز Cr في النهرِ ضمن الحدودِ المقبولةِ في الأنهارِ والماءِ الصالح للشربِ، بينما تَتجاوزُ تراكيز Pb في النهرِ الحدود المقبولة في الأنهارِ والماءِ الصالح للشربِ. أيضاً، مطروحات معمل نسيج ألحله تؤثر على توزيع تراكيز المعادنِ الثقيلةِ على طول مجرى النهر بعد مصبِّ مطروحات المعمل بشكل زيادة تدريجية في تراكيز المعادنِ الثقيلةِ الموجودة في مطروحات المعمل.

Introduction:

Toxic metals are present in only minute quantities in most natural water systems. Even in small quantities, toxic metals in drinking water are harmful to humans and other organisms. It may be dissolved in water and cumulative toxins such as arsenic, cadmium, lead, and mercury. These particularly hazardous metals are concentrated by the food chain and pose the greatest danger to organisms near the top of the chain.[1,2] In summary, all living organisms within a given ecosystem are variously contaminated along their cycles of food chain.[3]

Heavy metals are major toxicants found in industrial wastewaters; they may adversely affect the biological treatment of wastewater. These contaminants must be taken into consideration in the design and operation of a biological treatment process. When introduced into a treatment process, toxic inorganic compounds can kill off the microorganisms needed for treatment and thus stop the treatment process.[1] In other side, Many of these metals are necessary for growth of biological life, and absence of sufficient quantities of them could limit growth of alga,[4] some of the metals like Cu, Fe, Mn, Ni, and Zn are essential as micronutrients for life processes in plants and microorganisms,[5] and trace metals such as mercury, copper, selenium, and zinc are essential metabolic components in low concentrations.[6]

Water pollution is most commonly associated with the discharge of effluents from sewers or sewage treatment plants, drains and factories to the water body of rivers. Hilla City is located on Hilla River which is the main water source. Textile wastes that released from Hilla textile factory contribute in pollution of Hilla River due to its contents of toxic metals and as a results of raw materials that used in textile industry. The production of textiles represents one of the big consumers of high water quality. As a result of various processes, considerable amounts of polluted water are released to Hilla River. Thus, this problem has an environmental concern due to water pollution by toxic chemicals present in textile waste effluents.

Wang et al. (2006) show that a representative magnitudes for water consumption are 100–200 L of water per kilogram of textile product. Considering an annual production of 40 million tons of textile fibers, the release of wasted water can be estimated to exceed 4–8 billion cubic meters per year.[7]

Many studied were done about Iraqi rivers pollution by the factories effluents such as Dawood B. S. (1980) studied the water pollution in Tigris River by Al-Asria tannery effluents[8], Kanber H. H . (1981) studied the and the effect of Mishrag wastewater on Tigris River quality[9], Al-Zubaidi (2007) studied the dispersion of pollutant in Shatt Al-Hilla River[10], and many others.

Commonly toxic metals in Hilla River and their healthy effects:

Metals have many sources from which they can flow into the water body. In general, these sources in Hilla River can be classified into natural, industrial, domestic, agricultural, solid waste, run off, and atmospheric pollution.

All point source and non-point source wastewaters at an industrial site must be properly managed for source separation, waste minimization, volume reduction, collection, pretreatment, and/or complete end-of-pipe treatment. When industrial waste is not disposed of properly, hazardous substances may contaminate a nearby surface water (river, lake, sea, or ocean) and / or groundwater. Any hazardous substance release, either intentionally or unintentionally, increases the risk of water supply contamination and human disease.[7] The major waterborne contaminants and some of their healthy effects are listed below:

- **Cadmium (Cd) :**

Only minute amounts of cadmium are found in natural waters in the United States. Hazardous waste discharges from the electroplating, photography, insecticide, and metallurgy industries can increase cadmium levels. Another common source of cadmium in drinking water is from galvanized pipes and fixtures if the pH of a water supply is not properly controlled. The sources of cadmium exposure are the foods we eat and cigarette smoking. The maximum amount of cadmium allowed in drinking water by the standard is 0.01 mg/L of water.[7]

- **Chromium (Cr) :**

Chromium is a transition element of sub-group VIA, and it can assume the oxidation states 0 (chromium hexacarbonyl) and I to VI. Apparently, chromium is commonly used as a coating for the protection of alloys and metals, owing to its high resistance to corrosive agents (electrolytic chromium plating). It is a constituent of oxidation-resistant, refractory, very hard alloy. It is also a constituent of alloys for electrodes and thermocouples.[11]

Chromium is commonly released to the environment from the electroplating industry and is extremely hazardous. Some studies suggest that in minute amounts, chromium may be essential to human beings, but this has not been proven. The standard for chromium is 0.05 mg/L of water.[7]

- **Lead (Pb) :**

Lead is mostly used in car batteries, as a coloring element in ceramic glazes, is a base metal for organ pipes and is used in the glass of computer as well as television screens. Lead is a non-essential element and is potentially hazardous to most forms of life and can be bio-accumulated by benthic bacteria, fresh water plants, invertebrates and fish. Enhanced levels of lead can lead to the disruption of the biosynthesis of hemoglobin and anemia, a rise in blood pressure, kidney damage, miscarriage (and subtle abortion), and brain damage.[12,13]

Also, lead sources include lead and galvanized pipes, auto exhausts, and hazardous waste releases. The maximum amount of lead permitted in drinking water by the standards is 0.05 mg/L of water. Excessive amounts well above this standard may result in nervous system disorders or brain or kidney damage.[7]

Toxic metals standard:

The EPA has established maximum contaminant levels (MCLs) due to toxic metals for drinking water.[1,2,14] This standards are something different in its MCLs with Iraqi specifications of public water and effluent wastewater to water resources according to the ministry of Iraqi health (1988)[15] and as recommended by the standard methods of testing and water analysis / collage of engineering / university of Babylon (2000)[16]. The standards of commonly toxic metals in Hilla River are collected from the references and listed in the table (1).

Table (1) : Contaminants standards of commonly toxic metals.

Contaminants	**Potable water (mg/L)[1,2,14]**	**Water resources (mg/L)[15,16]**	**Wastewater effluent to water resources (mg/L)[15,16]**
Cadmium (Cd)	0.01	0.005	0.01
Chromium (Cr)	0.05	0.05	0.10
Lead (Pb)	0.05	0.05	0.10
Nickel (Ni)	0.10	0.10	0.20

Study area and sampling program:

The study was carried out on Hilla River**.** Four locations of sampling took from the middle of the Hilla River, 30 cm below water surface, starting in front of the outfall of Hilla textile factory. The distance between each location 150 *m*. The locations of sampling and the distance between them are shown in a schematic view of the study area in figure (2). A sample was taken from the Hilla River, at a distance 100 *m* before the outfall of Hilla textile factory, to identify the natural concentrations of heavy metals in Hilla River. During the survey, all points of sampling stations were noted on the bank of the river. The sampling was repeating each mid month, once each month, for a six months starting from the dry and hot weather conditions in August / 2010 to the wet and cold weather conditions in January / 2011. These weather conditions represent the predominating weather conditions in Iraq. The sampling was done according to the standard methods of testing and water analysis / collage of engineering / university of Babylon (2000)[16] and according to American Public Health Association (APHA)[17].

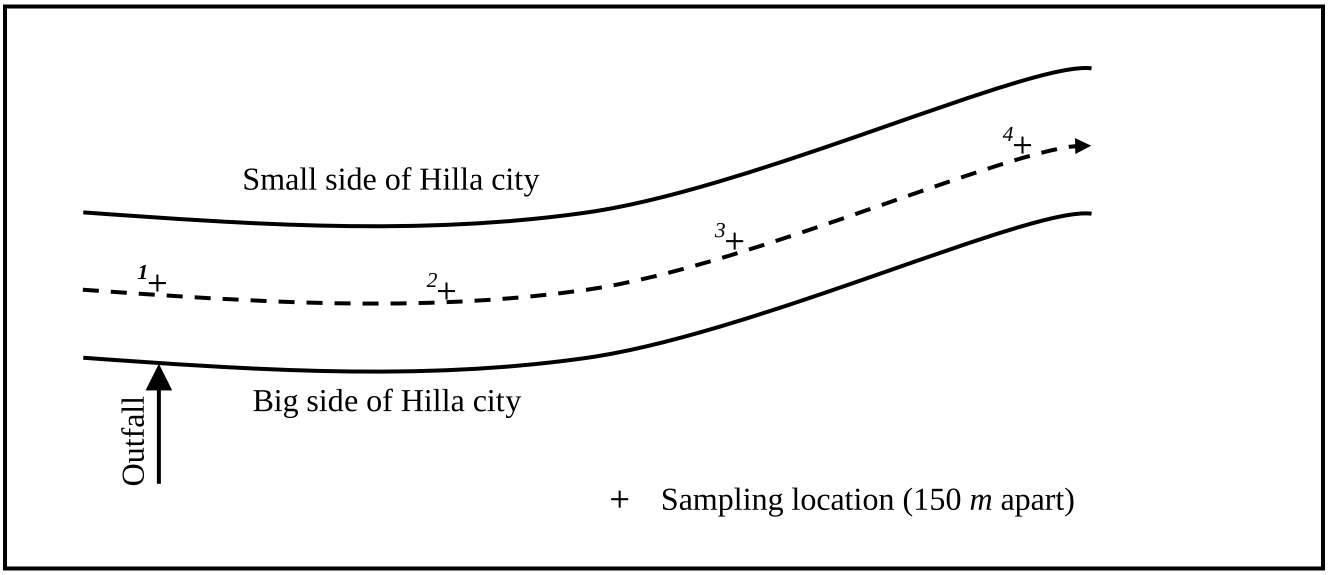

Figure (2) : Schematic view of Hilla River, study area and sampling location.

Laboratory tests:

Samples for the heavy metals analysis were collected in 500 mL glass container which were initially washed with detergent and rinsed with distilled water.

Samples were acidified at the time of collection with a concentrated nitric acid (1.5 ml HNO_3/l sample) to get pH of 2 or less to prevent metal depletion[17]. The tests were done in labs of the environmental ministry by using device of atomic absorption spectrophotometer type PYEUNICAM SPG. The concentrations of selected toxic heavy metal, chromium (Cr) and lead (Pb), were determined for each location in figure (2). Chromium (Cr) and lead (Pb) are the major risky heavy metals in Hilla Textile Factory effluent and within the study area no outfalls can be considered as a source for Cr or Pb. The wavelengths set for each metal were: Cr-357.9 nm, and Pb-217.0 nm. The experimental works data and its average value for a time period of six months are collected and summarized in table (2), and table (3).

Table (2) : Natural concentrations of Cr, and Pb in Hilla River.

Heavy metals	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Average
Cr (mg/L)	0.003	0.004	0.0033	0.002	0.0022	0.0021	0.0027
Pb (mg/L)	0.008	0.02	0.0275	0.004	0.0075	0.0125	0.0132

Table (3) : Concentrations of Cr, and Pb in Hilla River at different location staring from the outfall of Hilla textile factory.

Location	Heavy metals	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Average
1	Cr (mg/L)	0.0029	0.0055	0.0044	0.0028	0.0029	0.0027	0.0035
	Pb (mg/L)	0.035	0.038	0.04	0.029	0.03	0.028	0.033
2	Cr (mg/L)	0.035	0.019	0.015	0.018	0.011	0.031	0.0215
	Pb (mg/L)	0.04	0.049	0.08	0.06	0.061	0.058	0.058
3	Cr (mg/L)	0.0038	0.017	0.02	0.025	0.028	0.021	0.0191
	Pb (mg/L)	0.044	0.05	0.056	0.051	0.039	0.04	0.0466
4	Cr (mg/L)	0.0028	0.0091	0.0064	0.0024	0.0019	0.0018	0.0041
	Pb (mg/L)	0.019	0.026	0.030	0.011	0.0210	0.022	0.0215

Results and discussion:

The experimental works and tests had been done for each location on Hilla River for a period of time, six months as explain before, the data of chromium (Cr) and lead (Pb) in table (3) are compared with the data of natural concentrations of chromium (Cr) and lead (Pb) in table (2) for each location in figure (2) and as follows:

- Figures (3 to 6) compare the variation of Cr concentrations with time for each location on Hilla River, see figure (2), with those of natural Cr concentrations in Hilla River. The results refer to the Cr concentrations is within the acceptable limits in the rivers and potable water which is 0.05 mg/L as recommended by he ministry of Iraqi health (1988)[15] and the standard methods of testing and water analysis (2000)[16], where the maximum Cr concentration is 0.035 mg/L which occurred during August at location number two, the minimum Cr concentration is 0.0018 mg/L which occurred during January at location number four, and the ranges of Cr concentrations values through various periods of time are (0.0027 – 0.0055 , 0.011 – 0.035 , 0.0038 – 0.028 , and 0.0018 – 0.0091) mg/L for the locations (1,2,3, and 4) respectively, see figures (3 to 6). Several countries reported levels of chromium (Cr) in water ranging from 0.1 μg/L to 15000 μg/L.[3]
- Figures (7 to 10) compare the variation of Pb concentrations with time for each location on Hilla River with those of natural Pb concentrations in Hilla River. The results refer to the Pb concentrations exceed the permissible limits which is 0.05 mg/L in the rivers and potable water (The ministry of Iraqi health, 1988; and the standard methods of testing and water analysis, 2000), where the maximum Pb concentration is 0.08 mg/L which occurred during October at location number two, the minimum Pb concentration is 0.011 mg/L which occurred during November at location number four, and the ranges of Pb concentrations

values through various periods of time are (0.028 - 0.04 , 0.04 - 0.08 , 0.039 - 0.056 , and 0.011 - 0.03) mg/L for the locations (1,2,3, and 4) respectively, see figures (7 to 10). Several countries reported levels of lead (Pb) in water ranging from 0.005 μg/L to 242.6 μg/L .[3]

- A gradually increasing in the concentration of both Cr and Pb with distance from the outfall can be observed through figures (3 to 10), starting from a simple increasing at location one which located in front of the textile factory outfall to a great increasing at location two and three which locate downstream of the textile factory outfall, and then the river begin to recover its natural Cr and Pb concentrations at location four which locate downstream of the textile factory outfall too. Many factor effect on this behavior and distribution of Cr and Pb with distance from the outfall, mixing process duo to diffusion and dispersion is the main mechanism in the transport of contaminants in rivers.[10,18,19]
- Figure (11, and 12) show the effect of Hilla textile factory effluent on distribution of heavy metals concentrations with distance along the river downstream the effluent outfall. It can be clearly observed that the maximum Cr, and Pb concentration locate at a distance about 250 m from the outfall region and the average Cr concentrations in Hilla River is within its acceptable limits in rivers and potable water, while the average Pb concentrations in Hilla River exceed the permissible limits in rivers and potable water.

Conclusions and Recommendations:

Conclusions:

- The levels of Cr, and Pb concentrations values through various weather conditions represent the predominating weather conditions in Iraq are compatible with its levels in several countries.
- The Cr concentrations in Hilla River are within its acceptable limits in rivers and potable water (0.05 mg/L), while the Pb concentrations in Hilla River exceed the permissible limits in rivers and potable water (0.05 mg/L).
- The Hilla textile factory effluent effects on the distribution of heavy metals concentrations with the distance along the river downstream the effluent outfall by a gradually increasing in the concentrations of heavy metals that is found in the effluent, such as Cr and Pb, starting from a simple increasing at the region which located in front of the textile factory outfall to a great increasing at the region which located at a distance about 250 m downstream the textile factory outfall, and then the river begin to recover its natural concentrations at a distance about 450 m downstream of the textile factory outfall.

Recommendations:

- The water treatment plants intakes which located on Hilla River and downstream the effluent outfall of Hilla textile factory must contain additional units to remove the heavy metals and to bring its concentrations to the acceptable limits in potable water.
- The environmental ministry must monitor the factories in Hilla City and classify the contaminants of each factory according to its toxicity and issue limitations with law to the control on river water pollution.
- It is necessary to test the waste of Hilla textile factory at the effluent outfall before the disposal to river water and monitored each constituent separately because for each constituent in the waste effluent there is acceptable limits mustn't access it. This can be done by constructing a lab near the effluent outfall.
- To prevent or decrease the effect of surfaces runoff on the presence of heavy metals in Hilla River, it is necessary to cover the banks of the river by stone or by grass coverage.

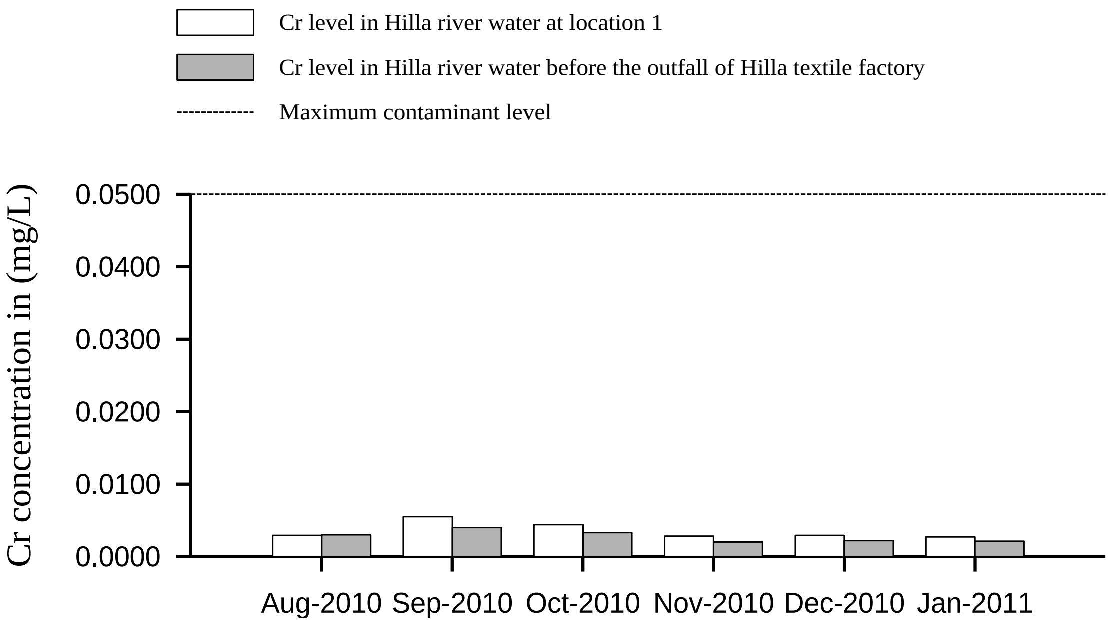

Figure (3) : Variation of Cr concentration with time at location 1.

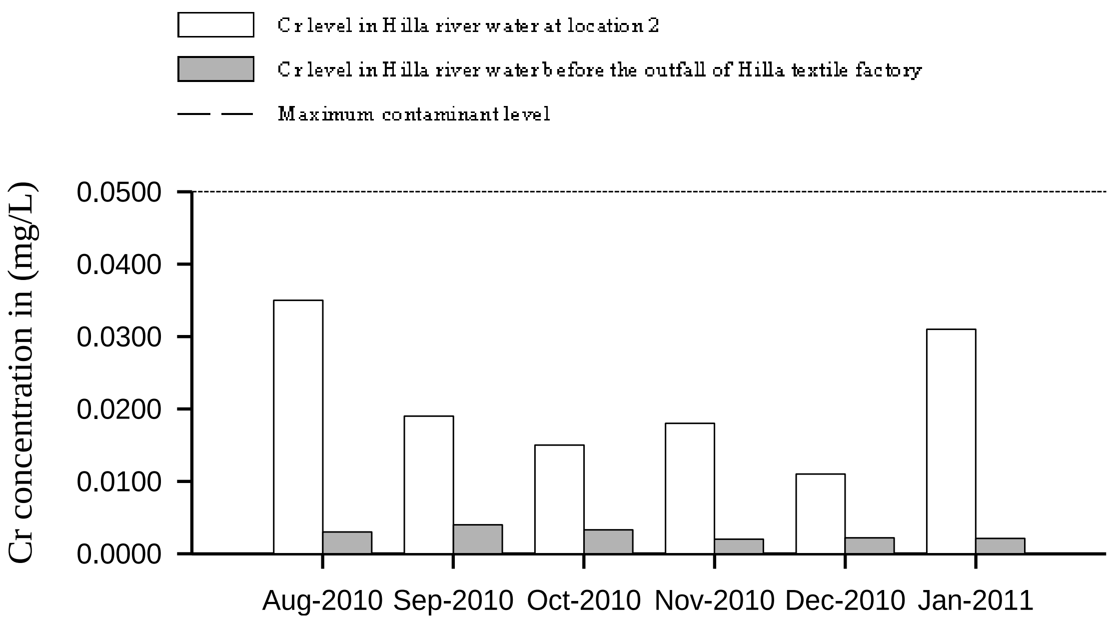

Figure (4) : Variation of Cr concentration with time at location 2.

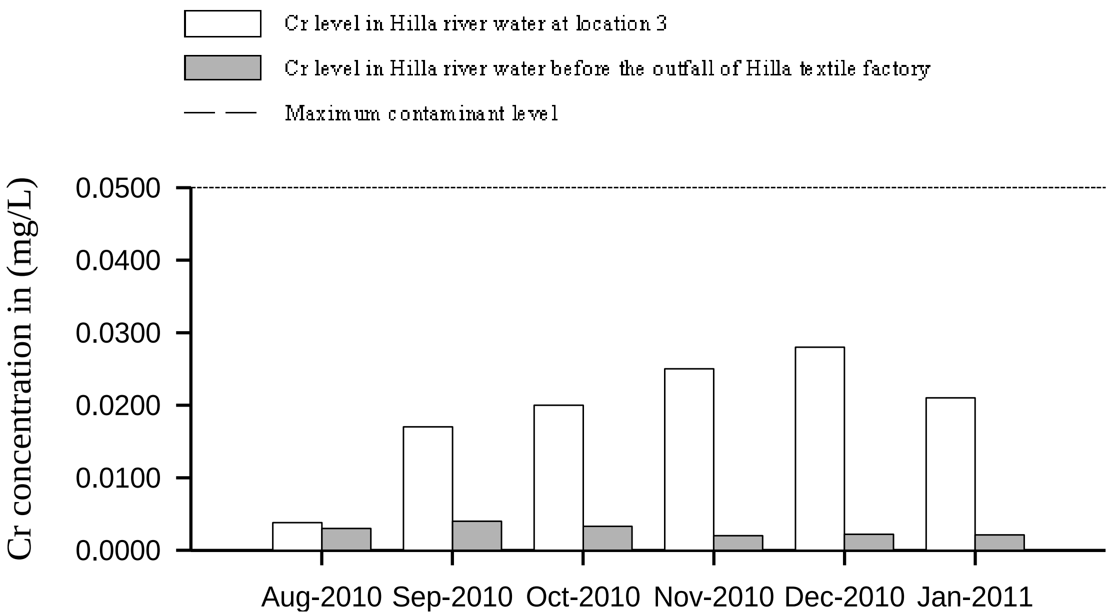

Figure (5) : Variation of Cr concentration with time at location 3.

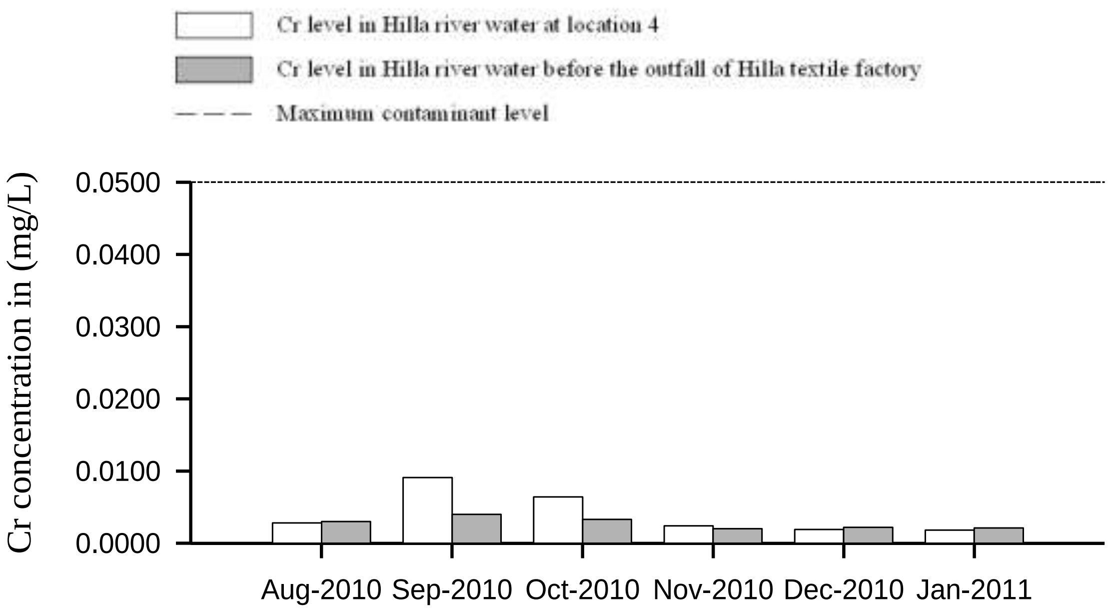

Figure (6) : Variation of Cr concentration with time at location 4.

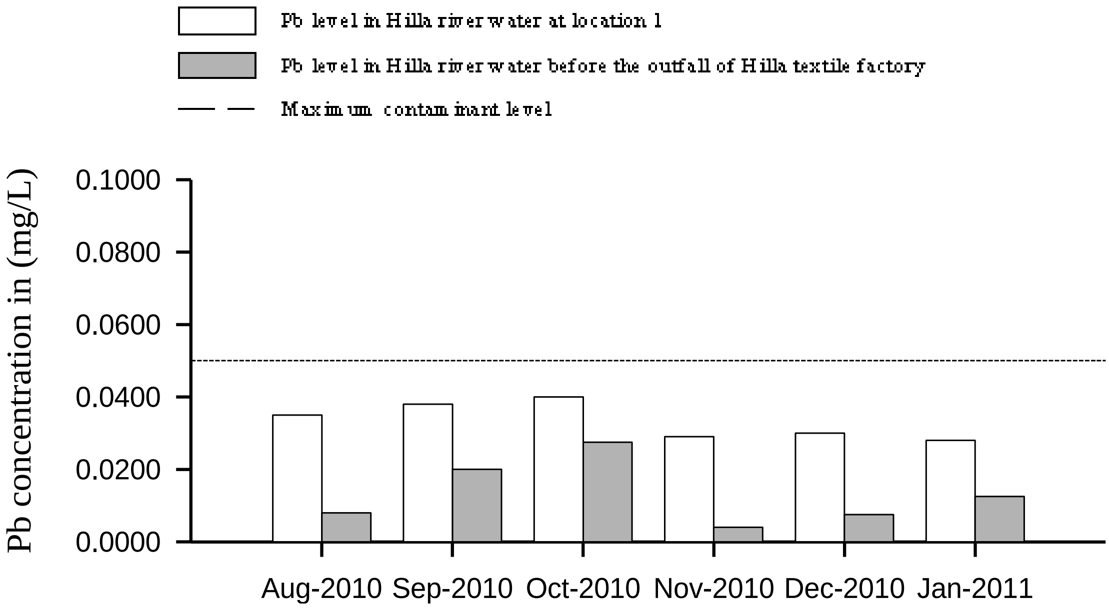

Figure (7) : Variation of Pb concentration with time at location 1.

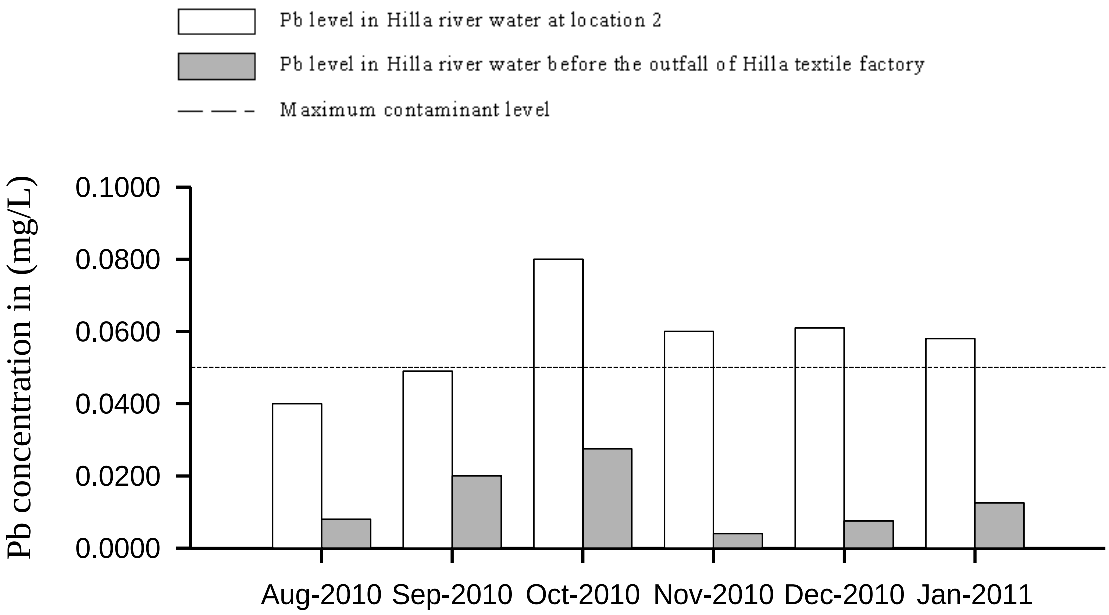

Figure (8) : Variation of Pb concentration with time at location 2.

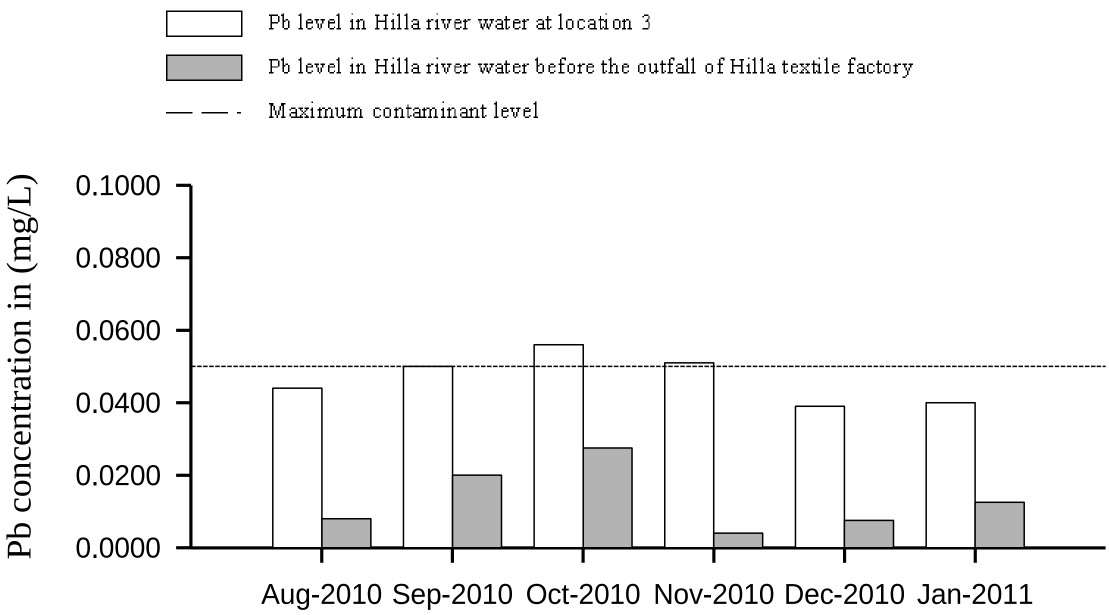

Figure (9) : Variation of Pb concentration with time at location 3.

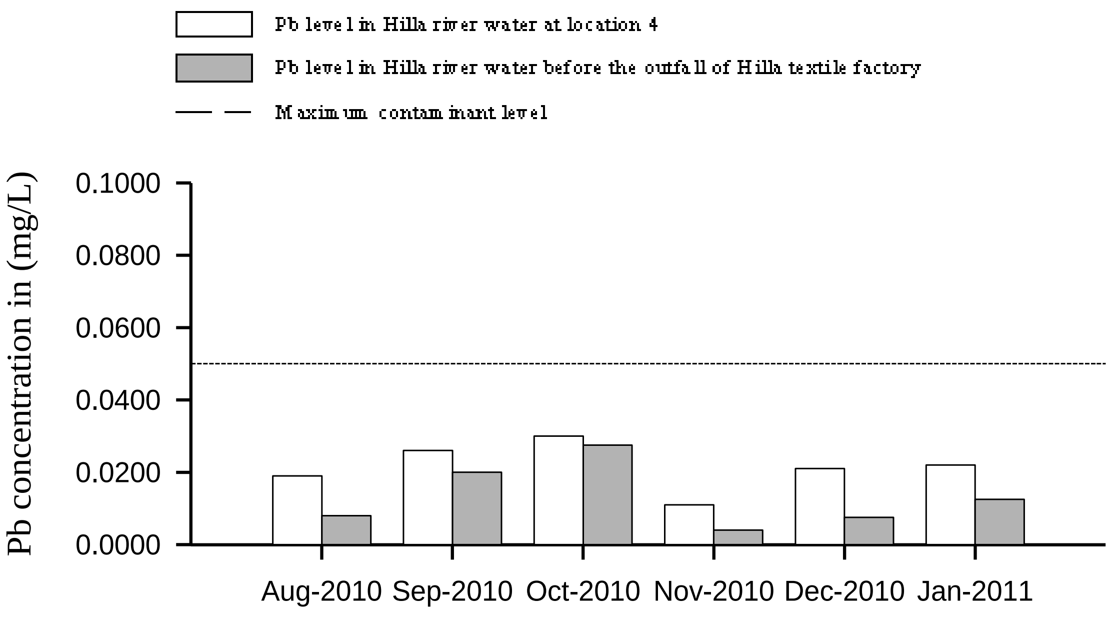

Figure (10) : Variation of Pb concentration with time at location 4.

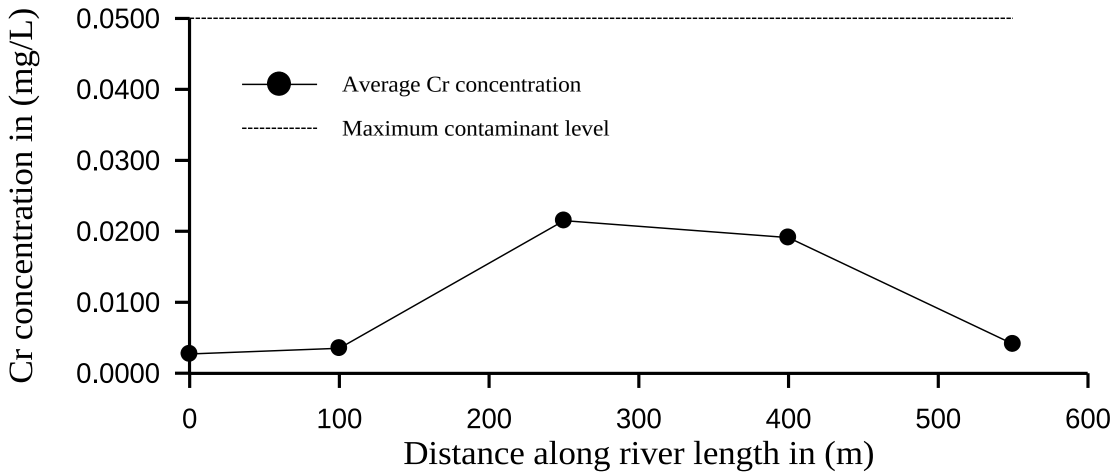

Figure (11) : Variation of average Cr concentration with distance.

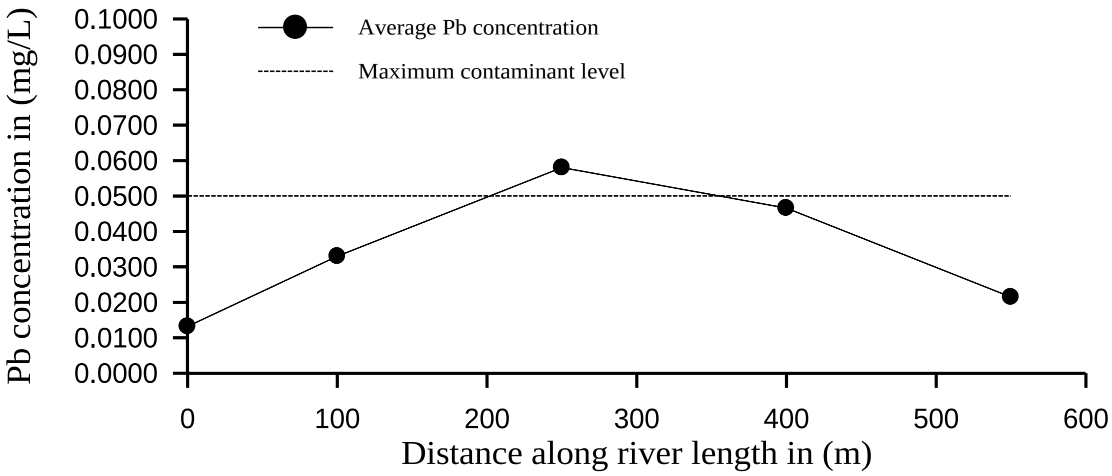

Figure (12) : Variation of average Pb concentration with distance.

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