

## Levels of Cr, Cu, Fe, Pb and Zn in Water-based Paints Manufactured in Pakistan

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**Summary:** The levels of four selected toxic elements; namely, chromium, copper, iron and zinc in various brands of water-based paints manufactured in Pakistan are reported. The analysis was done using the Flame Atomic Absorption Spectrophotometric method. The concentration of iron was especially high in all the paints under investigation.

### Introduction

Water-based paints are aqueous suspension of slaked lime together with a protein binder that provides better wash resistance to the paint. Additional preservatives, inert pigments and lime proof tinting materials are invariably added to modern formulations of water-soluble paints. The pigments comprising mostly of oxides of lead, chromium, iron and zinc pose a direct health hazard to humans since they constitute a major proportion of paint flakes that peel off from the painted surface due to the aging process. The toxic effects of these metals dispersed in paint dust are well known, especially for children who are easily vulnerable to the toxicity of the metals [1-4]. Heavy contamination of the dust and soil around houses renovated with such paints has been consistently reported. More recently, clinical and epidemiological studies have revealed that long-term exposure to these metals may lead to disorders of brain, kidney and nervous system, correlated with reduced IQ in children [5-7].

The objective of the present work was to evaluate the extent of these metals in water-based paints available at the retailer in local markets of Pakistan. On the basis of an initial survey aimed at identifying outlets of paint manufacture and distribution in the country, eight industries were identified for procurement of samples, selecting five popular colors (blue, green, red, white and yellow) for analysis. The study aimed at assessing the present status of the toxic metal content of these paints, so that a base-line data body could be evolved to evaluate the quality of locally manufactured paints against allowed permissible metal levels for safe use,

and to propose measures for future safety for an important industrial sector.

### Results and Discussion

The results of the present study in terms of concentration of the four selected metals in various brands of paints of different colors are given in Table-1 through 4, alongwith relevant statistical parameters, such as mean, SD, CV, min, and max. The metal to metal correlation data is described in relevant parts of this section.

Table-1 summarizes the level of chromium in water-based paint samples. Considerable concentration of chromium was found in all brands/colors, and especially in three brands namely green, emerald and gray color. In one brand namely PWG of paints the concentration of Cr found is in large amounts. Generally, the concentration of chromium in emerald, gray and green is high as compared to red and pink color in most of the brands. This low concentration could be due to the contamination in the raw material or during the manufacturing process. The average concentration of chromium found in gray paints is 65.98 mg/kg, while in the emerald it is 63, in the green 65 and in red it is 56. The minimum and maximum concentration detected in eight brand ranges from 0.0 to 228.34 mg/kg with coefficient of variation and standard deviation of 105.11 and 69.35 respectively. The data supports that most of the paints contain chromium, which could be potentially hazardous to human health and the environment in general.

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Table-1: Levels of chromium and relevant standard deviation pertaining to base paints manufactured in Pakistan

Brand Code	Concentration (mg/kg)				
	Green	Emerald	Gray	Red	Pink
W-1	113.28	16.74	28.20	57.01	30.51
W-2	61.12	44.95	17.73	11.28	14.84
W-3	56.68	46.96	115.28	95.05	105.52
W-4	BDL	94.92	61.81	84.83	54.30
W-5	23.10	54.83	34.89	28.57	14.18
W-6	69.98	14.29	41.58	63.07	82.40
W-7	123.45	229.81	228.34	98.82	131.47
W-8	69.88	BDL	BDL	8.26	0.6
MIN	BDL	BDL	BDL	8.27	1.0
MAX	123.45	229.81	228.34	98.82	131.47
MEAN	64.69	62.81	65.98	55.86	54.25
S.D	38.50	68.90	69.35	34.04	44.55
C.V	59.52	109.69	105.11	60.94	82.11

Table-2: Levels of copper and relevant standard deviation pertaining to base paints manufactured in Pakistan

Brand Code	Concentration (mg/kg)				
	Green	Emerald	Gray	Red	Pink
W-1	59.47	53.95	6.01	BDL	BDL
W-2	104.64	100.23	1.47	5.26	3.55
W-3	49.22	42.85	BDL	BDL	BDL
W-4	38.10	2.63	BDL	BDL	0.86
W-5	60.93	68.96	21.62	1.22	2.74
W-6	97.44	452.37	BDL	3.21	BDL
W-7	71.82	22.18	BDL	BDL	165.94
W-8	33.12	BDL	23.07	17.65	BDL
MIN	33.12	BDL	BDL	BDL	BDL
MAX	104.6	452.4	23.07	17.65	165.9
MEAN	64.35	92.90	6.52	3.48	21.69
S.D	24.25	139.5	143.2	162.0	251.4
C.V	37.68	150.2	143.2	162.0	251.4

Table-2 summarizes the concentration of copper in most brands of emerald color, which is found very high i.e. from 0.0 to 452.4 mg/kg. In green color of different brands, the concentration range is from 33.12 to 104.64 mg/kg. Red and gray color contains copper in negligible amount. The concentration of copper detected in these colors could be due to impurities in raw material or contamination during the manufacturing process which could not be ascertained due to trade secrets. The mean level of Cu found in green, emerald, gray, red and pink color is 64.35, 92.90, 6.52, 3.48 and 21.69 respectively. While the minimum and maximum concentration of Cu in green and emerald are 33.12 to 104.64 and 0.0 to 452.37 mg/kg respectively. The data predicts that Cu containing compounds are used as pigments for green and emerald paints.

Table-3 summarizes the concentration of iron in water based paints. The highest concentration of iron was found in four colors of four companies and in gray color of one brand. While the average concentration of iron found in all colors of all brands is high. The average concentration of iron in green color is 2122.25 mg/kg, while minimum and maximum values is found in green color are 161.22 mg/kg and 4823.98 mg/kg. In gray color the average concentration found is 961.28 mg/kg and minimum and maximum values are 139 and 4897.36 mg/kg respectively. The data shows that the concentration of iron in all studied brands is high comparable to other metals.

Table-3: Levels of iron and relevant standard deviation pertaining to base paints manufactured in Pakistan

Brand Code	Concentration (mg/kg)				
	Green	Emerald	Gray	Red	Pink
W-1	3832	574.1	4897	226.1	461.7
W-2	413.3	259.3	295.0	258.2	296.8
W-3	3433	569.3	702.2	155.0	473.0
W-4	4824	433.6	627.9	640.8	3904
W-5	161.2	150.6	139.0	153.5	157.6
W-6	322.5	281.4	536.9	237.1	720.1
W-7	273.3	276.4	238.6	370.0	573.2
W-8	3719	1660	253.2	3779	289.4
MIN	161.2	150.6	139.0	153.5	157.6
MAX	4824	1660	4897	3779	3904
MEAN	2122	525.5	961.3	727.5	859.5
S.D	1868	451.6	1500	1163	1163
C.V	88.02	85.94	156.0	159.8	135.3

Table-4 gives levels of zinc in various paint samples. High concentration of Zn was found in one brand of gray color and one brand of pink color, while in rest of the samples, the concentration of Zn is comparatively low with an average value in the range of 5.56 to 54.0 mg/kg. The mean value of Zn in eight different brands of green, emerald, gray, red and pink color is 11.46, 6.05, 54.06, 5.56 and 50.48 mg/kg respectively. The data reveals that paints are not a major source of Zn contamination.

The correlation between metals in emerald color between Cr and Zn is 0.83, whereas, in gray color this value is 0.24. The value of correlation in red color between Cr and Zn is 0.34, and between Cu and Fe is 0.93. The value of correlation in pink color between Cr and Cu is 0.64, between Cr and Zn is 0.64 and between Cu and Zn is 0.99. The high correlation value of 0.99 supports that the

Table-4: Levels of zinc and relevant standard deviation pertaining to base paints manufactured in Pakistan

Brand Code	Concentration (mg/kg)				
	Green	Emerald	Gray	Red	Pink
W-1	6.76	7.35	25.71	6.47	5.89
W-2	4.60	2.54	2.35	0.7	2.76
W-3	5.30	1.24	348.6	1.30	1.89
W-4	10.06	10.01	BDL	3.33	8.99
W-5	2.10	1.12	3.41	4.59	6.41
W-6	1.18	7.05	3.38	3.50	5.42
W-7	25.23	14.22	10.97	17.89	359.0
W-8	36.47	4.86	38.0	6.74	13.77
MIN	1.18	1.12	BDL	0.67	1.89
MAX	36.47	14.22	348.6	17.89	359.0
MEAN	11.46	6.05	54.06	5.56	50.48
S.D	11.82	4.28	112.04	5.08	116.7
C.V	103.7	70.71	207.3	9.135	231.1

compounds of Cu and Zn are being used in the manufacturing of pink colored paints. The US, EPA has restricted the use of metal levels arising from pigments/paints to an allowed limit through TCLP program. Accordingly, the permissible limit for Fe and Zn is 5.0 mg/L and for Cu and Cr 3.0 mg/l [8].

### Experimental

Research grade chemicals were used through out the investigation. Nitric acid (70% w/w) of May and Baker was used. Whatman filter paper 540 was used for filtration. Different salts and standards used for quantification were obtained from Merck, and were of analytical grade. For each trace metal, aqueous standard solutions were prepared by dissolving an accurately weighed amount of the relevant salt in deionized water so as to yield a metal ion concentration of 1000 ppm. Appropriate aliquots were taken from these standards for subsequent dilution to the desired concentration level. Each time the standards of low concentrations were prepared freshly.

Samples of approx. 0.5 g were taken in a pre-washed beaker, dried and then ignited in a furnace at 475°C for three hours to remove organic contaminants. Samples were then allowed to cool in a dessicator. Each sample was treated with 20 ml of (1+1) 70% nitric acid and digested for one hour at 70°C. The digest was filtered and diluted with distilled water to a final volume of 50 ml. Unicam

Atomic Absorption spectrometer (model 929) was used for analysis of the samples. Working standard solutions were made up in the range of 2 to 100 g/ml depending on the type of paint to be analyzed. A calibration curve of absorbance vs. concentration of the metal was drawn and the concentration of the unknown samples was made under strict optimization of wavelength and bandwidth. Under the conditions, the detection limits for various metals are Cr (0.05 ppm); Cu (0.01 ppm); Fe (0.01 ppm) and Zn (0.001 ppm). All glass wares used for processing of the samples or for the preparation of standards, were thoroughly washed once with detergent solution, tap water, thoroughly rinsed with (1+1) nitric acid, and finally with deionized water and kept for 6 hours in an electric oven at 150°C prior to use.

### Conclusion

In conclusion, the study shows that for most paints analyzed, the toxic metals remain by far undesirable from the viewpoint of human health and safety. There are some brands of paints in which the concentration of metal ions are not high but there is a need to investigate the concentrations of other chemicals that could be organic in nature and affecting the environment in some other way.

### References

1. R.L. Bornschein and P.A. Succop, Trace substances in environmental health, Proceedings of Univ. of Missouri, Colombia, USA 322 (1986).
2. N. Kim and J. Fergusson, *New Zealand Sci. Total Environ.*, **138**, 1, (1993).
3. J.E. Peterson, *Occup. Med.*, **8**, 533 (1993).
4. L.M. Conroy, P.M. Sullivan, R.M. Menzes, S. Cali and L. Frost, *Arch. Environ. Health*, **51**, 95 (1996).
5. M.J. Levette, *Chem. Britain*, **20**, 986 (1984).
6. M. Gough *Chem. Matters*, **1**, 4 (1983).
7. J.D. Bogden and D.B. Louria, *Bull. Environ. Contam. Toxicol.*, **14**, 289 (1975).
8. J.A. Kent (ed.) *Riegel's Handbook of Industrial Chemistry*, Chapman and Hall Publishers, New York 9th edition (1994).