Contamination of Toxic Heavy Metal in Locally Made Plastic Food Packaging Containers

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Abstract- Human exposure to toxic heavy metals creates a major health hazards. The main objectives of our study was to examine the concentration of toxic heavy metals like Lead (Pb), Copper(Cu), Nickel(Ni), Zinc(Zn), Manganese(Mn), Chromium(Cr) and Cadmium(Cd) in locally made food containers purchased from various districts of U.P (India). All samples are analyzed at 60±2°C for 2hrs in different simulating solvents as per BIS, IP, USP and other guidelines by using atomic absorption spectrophotometer(AAS). The results shows that leaching of heavy metals occur in all samples and follows the order:

\[ \text{Pb}(1.9-0.0001 \text{ ppm}) > \text{Cu}(1.61-0.0001 \text{ ppm}) > \text{Ni}(1.31-0.001 \text{ ppm}) > \text{Zn}(1.02 -0.001 \text{ ppm}) > \text{Mn}(1.01-0.0001 \text{ ppm}) > \text{Cr}(0.14-0.0001 \text{ ppm}) > \text{Cd}(0.01-0.0001 \text{ ppm}). \]

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GJSFR-B Classification : FOR Code: 250201

Strictly as per the compliance and regulations of :
Contamination of Toxic Heavy Metal in Locally Made Plastic Food Packaging Containers

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I. Introduction

Plastic containers used for food packaging are made from plastics based on the following polymers: polyethylene(low and high density), polypropylene, polyvinyl chloride, polystyrene etc. All plastics, apart from basic polymer, contain additional chemical compounds called additives (plasticizers, antioxidants, stabilizer, curing agent, colouring agent etc) which are added in small amount to attain certain desired properties. The final processed plastic is slightly different material as compared to the virgin polymeric plastic. These additives possess mobility and likely to transfer some low molecular weight non polymeric components into the packaged content under the influence of physicochemical factors such as sunlight, temperature, type of solvents (based on nature of food) and pH of the stored material\(^\text{1-8}\). Thereby contaminating the food with the risk toxic health hazard to the consumer. Therefore, the guidelines for the proper use of plastic have been formulated all over the world and BIS formulate the national standard\(^\text{9-17}\). According to this, metal content should not be more than 1ppm and Cd should not be more than 0.1ppm. Therefore, it is necessary to determine the concentration of heavy metals such as Zn, Ni, Mn, Cu, Cr, Cd and Pb in locally made food containers to safeguard the health of a consumer.

Various studies have done on leaching of heavy metal from food containers and found that the concentration of heavy metal is beyond the allowed limit\(^\text{5,18}\). Since heavy metals cannot be metabolized easily by the human body because it is five times more dense than water. Therefore, it can be accumulated in the body and when their concentration cross their permissible limit, can become harmful and causes toxic health hazards such as disorders in mental function, kidney, nervous system, respiratory system and many other physiological activities of the body cells and other organs\(^\text{19-23}\).

Due to large consumption of plastic in India, several small scale industries forming plastic food container in irregular way by using harmful additives which are usually above their allowed limits and these product are generally not tested by regulatory agencies for safety of consumer. This leads to reduced quality of product. In the regard, this research was designed to determine the concentration of heavy metals like Zn, Ni, Mn, Cu, Cr, Cd and Pb in local made food container which were purchased from various districts of U.P., India.

II. Material and Methods

Thirty samples of five different brands of food containers were purchased from various districts of U.P, India, for the assessment of heavy metals (Zn, Ni, Mn, Cu, Cr, Cd and Pb). The food containers were washed thoroughly with sterilized double distilled water prior to leaching. Based on nature of food, five different food simulating solvents are used and these are Double distilled water, Acetic acid (3% v/v), Ethanol (8% v/v), Sodium chloride (0.9% w/v) and Sodium carbonate (5% w/v). The food containers were exposed in 100ml of each simulating solvents in a sterile beaker at a ratio of 1 cm\(^2\)/2 ml. The samples were kept at 60 ±2°C for 2 hours. Parallel sets having simulating solvents only served as basal control were also run under identical conditions. The stimulant solvents (100ml) were taken in 1 cm\(^2\) beaker and digested in a fuming chamber using concentrated nitric acid. The digested samples were make up to 10ml using 0.1N HNO\(_3\). The quantitative analysis of final digested samples were done by using Perkin-Elmer-500 atomic absorption spectrophotometer (AAS). The instrument was first calibrated with standard solution prepared from stock solution as provided by Merck. The metals concentration of different leachates of samples were determined in triplicate and the result is given as a mean ±SD. The heavy metals concentration

\(\sigma\)
of different samples are presented in ppm. The concentration of metal should not be more than 1 ppm (Cd should not be more than 0.1 ppm) according to BIS, IP, USP and other regulatory agencies.

### III. Results and Discussion

The results showed that all samples were found to contain Zn, Ni, Mn, Cu, Cr and Pb in varying concentrations are given in Figure 1 to 5.

* The mean concentration of Zn which is above allowed limit (1 ppm) in the samples follows the order: 
  * S2 (1.02 ppm in 3% acetic acid) > S4 (1.006 ppm in 0.9% NaCl).

* The mean concentration of Ni which is above allowed limit (1 ppm) in the samples follows the order:
  * S4 (1.31 ppm in double distilled water) > S3 (1.21 ppm in double distilled water) > S2 (1.102 ppm in 3% acetic acid) > S2 (1.08 ppm in 0.9% NaCl) > S5 (1.02 ppm in 5% Na$_2$CO$_3$) > S5 (1.01 ppm in 3% acetic acid).

* The mean concentration of Mn which is above allowed limit (1 ppm) in the samples follows the order:
  * S5 (1.01 ppm in 0.9% NaCl) > S2 (1.008 ppm in double distilled water) > S3 (1.001 ppm in double distilled water). The concentration of Mn was not detected in case of 8% Ethanol.

* The mean concentration of Cu which is above allowed limit (1 ppm) in the samples follows the order:
  * S5 (1.61 ppm in 3% acetic acid) > S4 (1.30 ppm in 0.9% NaCl) > S4 (1.02 ppm in double distilled water).

* Except in case of 0.9% NaCl, all samples were found to contain Cr under permissible limit. The highest mean concentration of Cr (0.14 ppm) was detected in case of 3% acetic acid.

* The mean concentration of Pb which is above allowed limit (1 ppm) in the samples follows the order:
  * S1 (1.9 ppm in double distilled water) > S3 (1.2 ppm in 3% acetic acid) > S5 (1.1 ppm in 5% Na$_2$CO$_3$) > S1 (1.04 ppm in 5% Na$_2$CO$_3$) > S1 (1.029 ppm in 8% ethanol) > S2 (1.002 ppm in 3% acetic acid).

* All samples were found to contain Cd under allowed limits (0.01 ppm).

The differences were significant between mean concentrations of metals in different food containers samples in double distilled water (P<0.05), 3% acetic acid (P<0.05), 8% ethanol (P<0.05), 0.9% NaCl (P<0.05) and 5% Na$_2$CO$_3$ (P<0.05).

Thus, the result shows that higher percentage of leaching of heavy metals above allowed limit follows the pattern:

Pb (1.9-1.002 ppm) in S1 > Cu (1.61-1.02 ppm) in S5, S4 > Ni (1.31-1.01 ppm) in S4, S3, S2, S5 > Zn (1.02-1.006 ppm) in S2, S4 > Mn (1.01-1.001 ppm) in S5, S2, S3.

Percentage of leaching in different food stimulant solvents shows the pattern:

*Double Distilled Water > 3% Acetic Acid > 0.9% NaCl > 5% Na$_2$CO$_3$ > 8% Ethanol.*

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**Figure 1:** The concentration of metals (ppm) in double distilled water at 60±2ºC for 2 hrs.

The result were reported as a mean ± SD from three set of experiments. *p<0.05
**Figure 2**: The concentration of metals (ppm) in 3% acetic acid at 60±2°C for 2 hrs. The result were reported as a mean ±SD from three set of experiments. *p<0.05

**Figure 3**: The concentration of metals (ppm) in 8% ethanol at 60±2°C for 2 hrs. The result were reported as a mean ±SD from three set of experiments. *p<0.05
**IV. Conclusion**

This report documented the exposure of human to toxic heavy metals through plastic food containers. The food containers purchased from various districts of U.P., (India), contain toxic heavy metals such as Pb, Cu, Ni, Zn, Mn, Cr, and Cd. Out of which the concentration of Pb, Cu, Ni, Zn, and Mn were above allowed limit that may creates a major health problems for consumer. Therefore, it is need to safeguard the health of consumer through awareness of society about harmful effects of plastic food containers, especially local made containers having no specification of additives.
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