

# Chapter 11

## Impact of Heavy Metal–Based Nanomaterials on Environment and Health: Small Things Having Big Impacts!

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### ABSTRACT

*Nanotechnology possesses a wide array of materials in the form of nano-tubes, fibres, plates, chips, particles, sensors, and so on; the application of which has dramatically increased over the last few years due to their unique physicochemical characteristics (i.e., catalytic activity as well as optical, electronic, antibacterial, and magnetic properties). However, the exposure to nanoparticles, and consequent threat to human health and the environment are valid concerns because of the magnitude of nanotechnology-based applications, mainly in the pharmaceutical industries during drug designing, targeted drug delivery and disease diagnostics, and manufacturing of commercial products. For this purpose, the majority of nanomaterials are synthesized either from carbon (organic) and/or heavy metals, metal oxides (inorganic). Accordingly, lead, zinc, copper, chromium, iron, cadmium, and their oxides are important inorganic nanomaterials that are discussed in the chapter.*

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## INTRODUCTION

In the 20<sup>th</sup> century, the word “nano” is equivalent to modernization, nanotechnology is the ‘apple-of-eye’ of every person working in the field of Science and Innovation on the basis of its promising and beneficial effects in every field of human endeavors such as, industry, agriculture, business, medicine and public health. According to the estimation at global level, it has been found that the nanomaterial market will be worth of USD 7.9 billion in 2020 and USD 12.1 billion by 2026, with 9.7% compound annual growth rate (Barhoum et al., 2022). As per the report of Barhoum (2022), the nanomaterial market size substantially expands during the period of 2021-2027 due to its implementation in the industrial sectors as shown in **(Figure 1A and 1B)**.

Nanomaterials are not something we are naive to; from the little activities of the beginning of our day such as, brushing our teeth using toothpaste to the natural phenomenon occurring at the end of our day like watching beautiful sunset are the result of nanomaterials (Hobson et al., 2016). Even in the ancient times, the existence of the nanomaterials in various events such as Lycurgus cup from the British museum, stained glass windows by Romans, swords by Damascans, etc. are recorded (Hochella et al., 2019). With the advancement of science and the possibility of the exploration of benefits of nanomaterials, day-by-day, there is an increase in the consumer and industrial products that ultimately result in a new branch of science, named “Nanotechnology”.

Nanotechnology is the manipulation of matter at the atomic level so that the final product exhibits diversified and unique physical, chemical and biological properties, leading to several applications. But, it is well-experienced that the manipulations are not always easily accepted by the nature; henceforth, though positive impacts possess by these “nano” products, one cannot ignore the big negative impact of these products that may have on human and environmental health in order to maintain sustainability.

Further, the susceptibility to nanoparticles (NPs), and resulting risks to human health and environment, are subjects of concern because of the vast applications of nanotechnology in different industries during drug designing, targeted drug delivery and disease diagnostics, as well as wide spectra of manufacturing the commercial products like toothpaste, sunblock creams and skin care, sports supplies, and textile paints, semiconductors, electric devices, beverages, edibles and agricultural items, building materials, etc. For this purpose, a large proportion of nanomaterials are produced either from carbon-based organic and/or heavy metals and metal oxides-based inorganic materials. Lead (Pb), cadmium (Cd), iron (Fe), zinc (Zn), copper (Cu), and their oxides like lead oxide (PbO), zinc oxide (ZnO), iron oxide (Fe<sub>3</sub>O<sub>4</sub>), and others are important in this respect. Due to their enormous use and toxic effects to not only the manufacturers but also the consumers and the environment, heavy metal-based nanomaterials impact a major concern throughout the world. For example, a profound negative impact at both cellular and tissue levels including ultra-structural changes in primary and secondary organs due to sub-chronic exposure of PbO-NPs through inhalation (Dumkova et al., 2017).

Although the properties can be different on nanoscale level for heavy metal-based nanomaterials due to the changes in magnetic properties, physical and chemical natures, electrical conductivity, etc., people working with nanotechnology in a wide horizon raises global concern because of their biodegradability, bioleaching, environmental exposure, etc., which causes negative impacts on health especially, in front-line workers of different occupations (Kurwadkar et al., 2015a; Colvin, 2003; Balali-Mood et al., 2021). Thus, to answer the above-mentioned concerns, nanotoxicology comes into action, which defines what products can expose threat to environment and public health, and to what extent that ultimately respon-

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