A Review on Environmental Nickel Contamination

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Abstract

Regular environmental releases of nickel (Ni) and its compounds are occurring. In addition to several human sources, nickel and its compounds are naturally occurring and may be found in the earth's crust, wind-blown dust, volcanic eruptions, and soil. Nickel emission into the atmosphere is caused by a variety of sources. Due to the usage of nickel and its compounds in a wide range of commercial and industrial goods, Ni may be found in practically all environmental matrices. A significant occupational pollutant, nickel is created through its fumes and certain volatile compounds. Human carcinogens, including nickel, are well-known. A summary of the numerous elements of nickel pollution of the environment has been attempted in this work.

Keywords: Climate, Toxicology, Contamination, Nickel, Particulate Matter.

Introduction

For the creation of everyday items like jewellery, electronics, and a variety of industrial equipment, nickel is a metal that is regularly alloyed with other metals. One well-known method for the dazzling mirror finish is nickel plating. Although there are a number of health risks that might arise in industrial and occupational settings. Due to many causes, the nickel emission in the air varies.

There are several species of nickel, but the three that are most closely associated with metal smelting, burning, and refining are Ni chloride, Ni subsulfide, and silicate. The increase in industrial and other commercial applications has caused Ni to come under more attention from researchers recently. Humans are becoming more and more exposed to Ni via the air, food, and water. An key pathway for occupational exposure to nickel that poses significant health concerns is inhalation. Due of the low intestine absorption, the gastrointestinal route is not as essential.

Urban traffic pollution has a significant negative influence on the health of employees who are exposed for extended periods of time while doing outdoor labour or other activities in busy areas, and it is a contributing factor in several fatal illnesses. Numerous studies have looked at the relationship between critical or ongoing exposure to pollutants like particulate matter (PM) that are present in urban traffic. When combined with adsorbent matter, particulate matter (PM) from urban pollution is mostly to blame for cardiovascular diseases. Inhaling PM slows the heart rate, which causes endothelial dysfunction, autonomic dysfunction, and an accelerated progression of atherosclerosis. The development of pro-inflammatory and pro-thrombotic pathways is followed by an increase in oxygen reactive species as one of the causes of cardiotoxicity caused by air pollution.

The nickel in city air is a byproduct of both natural and manmade processes, including coal combustion, nickel processing, car traffic, home heating, and waste product burning. It is also adsorbed on particulate matter (PM). In addition to being utilised as an additive in unleaded petrol and as a catalyst in catalytic converters, nickel may also be found in solvents, paints, insecticides, and electronic devices.

Workers that spend a lot of time in metropolitan areas for job purposes, such as taxi drivers, salespeople, firemen, traffic police, etc., are thus exposed to particulate matter (PM). It is preferable to use biomarkers for this purpose that is designed to assess the contaminants.

Nickel is present in high concentrations and is regarded as a heavy metal pollutant because of its various adverse responses and consequences, including vomit, dry cough, irregular breathing, and fatigue among the effluents of electroplating businesses (tune of 20200ppm).

Occurrence in nature

Due to its ductility, hardness, melting point, and malleability, nickel interacts with other elements readily to create a variety metal alloys. Nickel also has strong strength, corrosion resistance, and heat resistance; it is abundant in meteorites and the terrestrial globe but relatively scarce in the crust of the Earth. The two ores of nickel are sulfuric and oxidic. Sulphidic ores are comparable to nickeliferous pyrrhotite (Fe Ss), pentlandite (Ni.Fe)9Ss, and chalcopyrite ($CuFeS_2$).The minerals violarite (NiFeS), ilmenite ($FeTiO_3$), pyrite (FeS_2), cubanite ($CuFe_2S_3$), and magnetite (Fe304) are among others that are also present in addition to these.

"Pentlandite" is one of the common sulphidic minerals that produces around 60% of the world's nickel. "Nickeliferous pyrrhotite" is regarded as the most abundant phase in nickel ore because nickel is often present in solid form (0.2-0.5%Ni). Finland, Zimbabwe, Australia, Canada, the Republic of South Africa, and the former Soviet Union are a few places where sulphidic orebodies are found.

Nickel is often found in the +2 oxidation state (divalent state) in aqueous solutions. It also exists in certain higher oxidation states (+3,+4), although these only ever occur as impure sesquioxide (Ni_2O_3) and dioxide (NiO_2), which is regarded as having an imbalanced, fluctuating stoichiometry. With a coordination number of 4 (rarely tetrahedral or square, planar), nickel functions as a transition metal that produces complexes.

Sources in Nature

Numerous studies have shown that the concentration of nickel in big natural particle sizes is comparably lower than that in smaller (1 m) anthropogenic-derived particles. Ni is released by anthropogenic sources such as the burning of coal, oil, and sewage from homes, hospitals, and factories. ii. Thermal metallurgical processes (nickel production, metal and nickel recovery). Production activities, iii. iv. Manufacturing of nickel-cadmium batteries (NI-Cd batteries), synthesis of nickel chemicals, electroplating, etc. are catalytic and chemical sources of nickel. Marine boats are significant suppliers of nickel in harbour regions.

The atmosphere's suspended particulate matter contains nickel-bearing particles; small airborne particles with a size between 0.6 and 10 m are often linked to nickel.

Air: In isolated areas, the amount of airborne nickel is between 0.00001 and 0.003 g/m3, whereas it is between 0.003 and 0.03 g/m in metropolitan areas.29. Particulate matter, heavy metal ions, nitrogen oxide, ozone, sulphur dioxide, and carbon monoxide are abundant in urban traffic and cause a variety of ailments, including high blood pressure and heart failure.

Nickel emissions into the air are also caused by the making of cement and coke ovens, although these are not the main sources.

Limestone, clay, and shale are the basic materials required in the high-temperature process of making cement. Nickel oxide, which was contained in these raw materials, was released throughout the procedure. Due to the highly reducing atmosphere of ovens28, metallic nickel and nickel sulphides are often released from coke ovens. Table 1a and Table 1b provide a few other, significant sources.

Table-1a: Sources of nickel in Atmospheric Air.

Natural		
Sources	Parentage Concentration	References
Windblown dust	56	30
Volcanoes	29	30
Vegetation	9	30
Forest fire	2	30
Meteoric dust	2	30

Table-1b: Sources of nickel in Atmospheric Air.

Anthropogenic		
Sources	Parentage Concentration	References
Burning residual and fuel oil	62	31
Metal and refining	17	31, 32
Municipal incineration	12	31, 32
Steel production	3	31, 32
Nickel containing alloy production	2	31, 32
Coal combustion	2	31, 32

Soil: Mafic and ultramafic rocks have the highest concentration of nickel33, with granite, lime stone, and sand stone having nickel concentrations ranging from 5 to 20 mg/kg. Nickel in soil is naturally produced through the mechanical and chemical weathering of rock material.

Large-scale industrial discharges of metal traces to soil have become a dangerous practise throughout much of the globe and have a negative impact on soil composition. In the soil (farm), nickel concentrations range from 3 to 1000 mg/kg, but because of the existence of refineries nearby, nickel concentrations have gone as high as 24 000 mg/kg and 53 000 mg/kg in dried sludge. Nickel compound solubility in soil depends on pH. At pH levels more than 6.7, nickel occurs as an insoluble hydroxide, whereas at pH levels lower than 6.5, nickel is soluble in soil.

Site-specific soil distribution of nickel exists. The distribution of nickel in soil surface is significantly influenced by the soil's texture, the presence of organic matter, the density of the minerals in clay, the presence of hydroxide, the movement of ground water, and ph. Nickel may be evenly distributed across the several soil horizons, however due to the washout effect of rain, it's conceivable that horizon B has a much higher concentration of nickel than horizon A. The pH of the soil and the geochemical quality are both decreased when nickel is combined with other heavy metals. It is crucial to maintain a procedural record and create a standard operating procedure (SOP) for monitoring heavy metals in order to regulate and suppress this kind of pollution.

Water: The globe and India both experience worrying levels of water pollution. In other nations, the reported data of nickel content in natural, ground water, and drinking water is presented in Table 2, however in India the acceptable limit for drinking water is 0.02 mg/l.

The condition of the pipe affects the quantity of nickel in drinking water. When using metal pipes, the concentration of nickel in hot water is lower than that in cold water, but when using PVC pipes, the concentration of nickel in hot water is higher than that in cold water. Due to modern stainless steel pipes' ability to leach nickel, the concentration may reach up to 6 g/liter. Adults consume between 0.0075 and 0.015 milligrammes of nickel per litre of water under typical conditions.

The increase in nickel in drinking water is caused by home appliances that have corroded nickel coating or alloy. The quantity of nickel in boiled water increased significantly as a result of significant amounts of nickel leaching into the water from nickel-plated utensils.

Table-2: Average Nickel concentration in water.

Country	Concentration	References
Netherlands (average concentration in ground water)	7.9µg/liter (urban area)	36
Netherlands (average concentration in ground water)	16.69µg/liter (rural area)	36
Canada (median level in drinking water)	2-60µg/liter	37
USA (median level in drinking water)	$<$20 µg/liter	38
Europe (median level in drinking water)	$<$10 µg/liter	38
Denmark (median level in drinking water)	1 µg/liter	39, 40
Finland (median level in drinking water)	1 µg/liter	39, 40

Food: The equipment and methods used to produce food, such as milling and catalytic hydrogenation of fat, boost the nickel level by lixiviation. Normally, it stays between 0.1mg/kg and 0.5mg/kg.

The abundant sources of nickel include dark chocolate, almonds, oats, soy-based foods, dried beans, and dried beans themselves. By include this meal in daily consumption, the daily intake of nickel rises to 900g per person per day (Table 3).

Sediments: The amount of nickel in sediment and soil is increased by man-made sources like fly ash and coal combustion ash, metallurgical processes like mining and smelting, commercial waste production, atmospheric deposition, urban refuse, and some natural sources.

Organic material, particles in crystalline form, coprecipitated, and precipitated particles that are utilised for coating are among the several phases of nickel that may be found in suspended solids and sediments.

The kind of inorganic and organic compounds that are used as nickel adsorbents, as well as their concentration and ionic strength, all have a significant impact on the dispersion of that particle.

Table-3: Nickel concentration in food material.

Type of Food	Nickel Concentration	References
Beans, seeds, nuts and wheat bran	1 – 6 mg/kg	46,47
Cacao	8 – 12 mg/kg	46
Whole meal product	0.1 – 0.4 mg/kg	46

General population exposure and impact

Food and water are the main sources of exposure to nickel, although respiration is one of the minor ones. Nickel for the general populace, the amount of nickel consumed regularly through food varies by gender, food type, age group, and nation.

According to estimates from the United States of America, daily consumption ranges from 107 to 109 g for females, 136 to 140 g for males, and 101 to 162 g for adults. Over hundreds of years, nickel and its alloy have been employed economically. The industries that utilise nickel for various operations (such as the production of stainless steel, welding, electroplating, cutting, and grinding, among other things) emit dust, fumes, and mist that include nickel during the milling, mining, smelting, and refining processes. Workers in these sectors are often exposed to the nickel fumes or mist created during production and processing, where soluble nickel is present in nickel-using industries and insoluble nickel is found in waste material in nickel-producing businesses.

Although numerous types of health issues, including lung, nasal, throat, and protest cancer, arise as a result of exposure to nickel in high concentrations. Shortness of breath, fast breathing, asthma, lung embolism, bronchitis, and even foetal abnormalities are brought on by nickel in gaseous form. Use of nickel-plated jewellery has been linked to skin allergies. The most common health issues seen include cardiac disorders, headaches, nausea, tightness in the chest, dry cough, chest discomfort, and excessive weakness.

Conclusion

Nickel is used more and more often in contemporary technology, which increases the amount of nickel in the environment.

The main causes are the quick rise in vehicle numbers, advancements in technology, and pollution releases.

The current research makes the case that it is crucial to routinely check the health consequences as well as the atmospheric air, soil, sediment, and water parameters.

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