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REVIEW
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E-Vehicles and Effects of their Chemical Constituents on Different Organisms

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Abstract

With the growing technology and changing face of the world where technology and innovation is showing its new side every single day, the world has been gifted with the new trend of E-Vehicles (a leading trend in the automobile sector now-a-days). But like the two sides of a coin, every innovation comes with two sides. The increasing use of E-Vehicles batteries, though as per sayings, have low or net zero carbon emission but the heavy cost of it lies in its after-use and disposal strategy. These vehicles although paving a way towards a new world without use of fossil resources and lesser carbon footprint but at the same time, they have hailed a new challenge of their waste management, recycling and disposal. Not only their recycling and disposal is the main headache but the harmful effusions, chemicals and metal ions released from them will contribute towards the environment already degrading health. The planet Earth is already facing several issues since industrialization and had lost its balanced state due to the increasing unavoidable human activities against the laws of nature and now the increasing replacement of conventional internal combustion engine with E-Vehicle batteries have burdened the Earth with more waste collection. The nations, in the race of achieving net zero carbon emission and increasing their dependency on renewable energy resources have forgotten to think about the consequences of the after-use collection of such heavy long-term liability of waste collection on the land. The environment and its organisms are already facing the problem of its previous waste dumping in the oceans and in the landfills and now a new collection of heavy waste have shown its face in the form of E-Vehicles battery waste that needs to be managed at just its initial phase. The objective of this review focuses on the environmental health, the harmful impact of chemicals released by the waste disposal of the batteries on the different organisms' along with the structural, functional and behavioral abnormalities caused due to these harmful chemicals.

Keywords: E-vehicles; Combustion; Lithium; Nickel; Fish; Lead; Earth; Chemicals

Introduction

Until the Glasgow summit of 2018, the use of e-vehicles was not an important concept. But after this summit and the declarations made thereof in the summit to increase the use of renewable resources and dependency on the non-conventional resources, the nations are running the race to achieve the net zero carbon emission as soon as possible and by any possible means. However, in this unhealthy race, they have eventually added a new tension of disposing the extra waste generated due to the non-conventional battery vehicles which requires an extra land and extra cost to planet Earth (Zhao and Baker, 2022). The increasing demand of Electric vehicles declares the increased demand and use of the metals like lithium, cobalt, copper, graphite, nickel, aluminium, copper and rare earth metals etc. in making the batteries causing upset in the supply and demand of these naturally occurring materials ultimately causing their price hike (m.coface.com). As the natural availability of these metals is limited, in future with the hike of demand of E-vehicles, how the companies could manage to satisfy the needs of manufacturers, producers and consumers. In order to satisfy the demand of these entities, more pressure will be put on mining of these metals and in turn the pressure will be shifted to the environment, leading the planet Earth and its people to pay a huge price.

In addition, some metals can be extremely harmful when finding their way into the environment and food chain. On their waste disposal into the landfills, the chemicals can leak out from the batteries, thus imbibing into the soil and contaminates the surface and ground water (Boyden, 2014). Once they enter into water bodies, bioaccumulation starts. Some of the dangerous effects of metals include- landfill fires due to lithium, resulting in the toxic chemicals release into the air; exposure to lead and strong corrosive acids can cause burns and harmful impact on eyes; nickel and cadmium are potential carcinogens; lead is known to cause various mental, developmental, neurological and inborn diseases (gsiwaste.com). In terms of energy, the initial process of mining & refining of metals then the process of assembling of the required entities into a battery demands huge amount of energy. In the whole process of making battery the Greenhouse gases emissions is high enough that is equivalent to the traditional amount generated in making the combustion vehicles with their on-road performance thus limiting their benefit to the climate in overall terms (Manzetti and Mariasiu, 2015). During manufacturing of vehicle battery, some harmful volatile compounds are generated like carbon monoxide, nitrogen oxides and fine particulate matter that get suspend in the air and degrade its quality (Vimmerstedt et al., 1995). In terms of aquatic environment, all the combined effect of mining, manufacturing etc. find its way to the aquatic bodies and affect the quality of water in terms of toxicity of water, altering its pH, harming aquatic plants and animals and causing eutrophication (Hawkins et al., 2013).

Types of vehicles

The sale of conventional cars in the year 2020 reduced by 6% while the sale of e-vehicles increased by around 41%. Next year, in 2021, the initial quarter, the sale of e-vehicles was 41% more as compared to the initial quarter of 2020 and this sale was expected to go 70% in the year 2022. Going according to the trend, it is predicted that the sale of internal combustion engine will get banned in some parts of the world by 2035 (Global EV outlook 2021). Previously there were only one or two types of vehicles used, but due to advancements in technology and manpower, different models and designs have been innovated from time to time to ease and modify the existing auto-mobile use. Today, there are different types of vehicles available in the market, some run on battery (these electric vehicles consist of battery which runs fully on electricity and can provide large capacity for travelling on roads), some on fuel (the fuel used to provide electricity is provided by Hydrogen fuel cell. The major advantage of this type of vehicle is that the by-product of fuel cell reaction gives water as a by-product which doesn't contribute to the green house emission), some on hybrid mode (These vehicles are the hybrid model of a conventional car engine and electricity-run-motor which are used alternatively according the situation in demand on road.

During a smooth run, the vehicle uses electric mode while during a difficult trip where demand is for a high power, it shifts to the engine mode power supply) and some have the feature of plug-in-hybrid model (These vehicles are similar in terms of usage of both electric motor and conventional car engine but the difference is that it uses electric motor as the main power source. During the turning on, these vehicles use the electric motor then runs on the battery installed but when the battery is getting out of energy, the engine supplies power to it which increases motor range for traction) (Chian et al., 2019). The vehicles that run on battery employ different types of chemicals to fuel their battery with the power supply and thus may vary in their features and utility. Lead acid battery (LAB) use lead as the primary energy material and were started in 1859 as a rechargeable battery. Another name for this battery is wet battery because it contains a liquid electrolyte like sulfuric acid. LABs are the most commonly used batteries because of its easy affordability and service. These batteries require very less maintenance and their life span can vary from 3-5 to 12+ years (Raj, 2018; Chian et al., 2019). SLI (Start, Lighting and Ignition) - These batteries are a type of lead acid battery and are rechargeable and runs the inbuilt internal conventional engine by providing a boost of power supply to it but also retaining its own power. The battery supplies power to each electronic system of the car and works for many years. VRLA battery (Value regulated lead-acid battery)- These also use lead material but these batteries come in seal form so ventilation of gases is not possible and hence its service cannot be done. These batteries are of two types- AGM (Absorbed Glass Mat) battery and GCB (Gel Cell Battery).

Nickel Metal hydride batteries are also rechargeable and are used in hybrid vehicles and have more life span than commonly used batteries. The components used in this type of battery are nickel cadmium cell (NiCd), nickel oxide hydroxide (NiOOH) (Iclodean et al., 2017). Silver Cadmium battery is a modified form of lead acid battery and use lead-cadmium silver plates and electrolyte. Lithium-ion and lithium polymer batteries are the most commonly used batteries both in electric and hybrid automobiles because of its several beneficial qualities like low self-discharge, optimal high temperature performance, high efficiency. Life Span varies from 5 to more years (Raj, 2018; Chian et al., 2019). This type of battery uses chemicals like- Lithium, cobalt, manganese, graphite, steel and Nickel. These components present inside the lithium battery contribute to some important element which helps to increase the efficiency of lithium battery. Lithium ions move from anode to cathode and generate power. Cobalt increases the life of battery, graphite constitutes the anode component, store lithium ions and also provide better life cycle stability and energy density. Nickel helps to provide a corrosion resistant environment along with dependable, effective spark and electrical systems (Enuh, 2022).

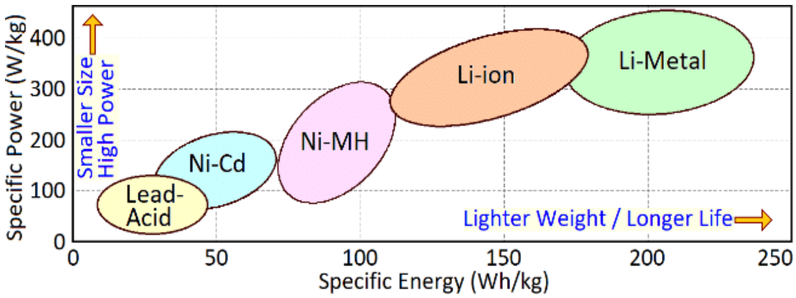

Fig.1. Power and energy capabilities of different batteries. (Vidyanandan, 2019)

All the types of batteries consist of some components which participate in a chemical reaction and fulfill the energy requirement of the vehicle. The components consist of two electrodes (a positive and a negative electrode), a separator, and an electrolyte system. The positive (anode) and negative (cathode) electrodes are made by mixing three components i.e. a conducting material (CM), a binding solution (BM) and an active material (AM).This mixture is coated on the side of electrode where current is collected (cathode). The anode material commonly consists of silicon, carbon black and graphite. The separator is a membrane whose work is to maintain distance between electrodes immersed in an ionic electrolyte solution that is conductive in nature. Commonly used separators are membrane of microporous polyolefin like Polyethylene (PE) (55), polypropylene (PP) (59), fluorinated polymers like PVDF along with its copolymers. LIBs commonly use electrolytes like Lithium tetrafluoroborate ($LiBF_4$), Lithium hexafluorophosphate ($LiPF_6$) and other high- grade lithium salts (Vidyanandan, 2019; Chian et al., 2019). Current collector works for the transfer of electrons in the electric circuit. Aluminium (Al) and copper (Cu) respectively are used as cathode and anode collector material for current due to their high stable nature and conductivity of electrons (Yang, Huang and Lin, 2022). In this review paper, we have discussed the effects of different chemicals used in battery vehicles on various aquatic and terrestrial organisms with the analyses of malformations and dysfunctions happening in their bodies due to entry of chemical waste from the battery vehicle disposal into their ecosystems and hence in their bodies.

Effect of nickel on organisms

The element nickel whether in ionic form or elemental form acts as a potential toxin for immune system and as a cancer-causing agent. In the ionic form (Ni^{2+}) contact with cell's nucleus can disturb or inhibit DNA exicison and repair mechanism, can lead to formation of Z- DNA and then can possibly lead to cancer formation by the process of mutation and chromosome damage (Campel and Nikel, 2006). A number of dangerous effects of nickel are noted on the human health like diseases of circulatory system, lungs, respiratory system (asthma, fibrosis of lungs, lung cancer) and skin diseases and skin allergies like stomatitis, dyshirotic eczema, contact dermatitis, labial desquamation, angular chelitis, numbness and loss of taste (Genchi et al., 2020). Disturbed mitochondrial potential with reduction of concentration of mitochondrial ATP and mitochondrial

ATP destruction noticed in the cells. Effect of nickel was also observed in the process of cell apoptosis in which nickel ions permits the release of Cyt C which helps in activation of main apoptotic enzyme (caspase-9) by cleaving the proenzyme (procaspase-9). An increase in cell death is a prime factor for so many neurodegenerative disease (Genchi et al., 2020). Nickel can have very lethal effects on the genes which may lead to heritable changes in the gene expression. These changes can be caused due to methylation of DNA, microRNA expression and modification of histone proteins that could only alter gene expression but not the sequence of DNA (Genchi et al; 2020). In plants, Nickel in excess concentration can cause necrosis and chlorosis with irregular iron (Fe) uptake and metabolism (Manzoor et al., 2022). Altered germination, dry matter production can be some negative effects of nickel on plants (Ghazanfar et al., 2021). Wild type p53 cells and mutant p53 cell patients (total 189) having lung cancer were selected to determine the nickel levels in their lung tissues by segregating the patients into high and low nickel subgroups. Result observed was the group having high nickel was at higher risk of p53 mutation with reduced DNA repair activity (Chiou et al., 2014).

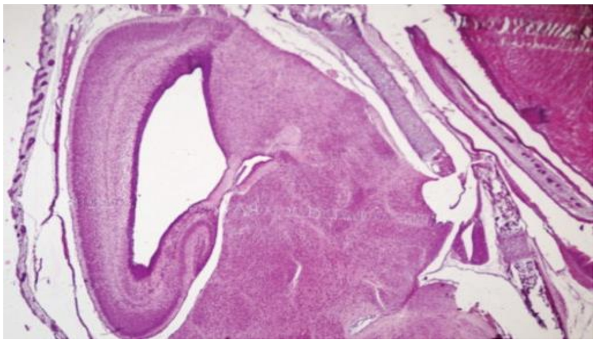

Fig. 2. Microphotograph of sagittal section of the fetal brain exhibiting hydrocephaly, that is, enlargement of ventricle (V) at the dose of 184.5mgNi/kg b.wt. as $NiCl_2 \cdot 6H_2O$. (Saini et al., 2013)

Fig. 3. Photograph showing fetus with umbilical hernia (Uh) at the dose of 184.5mgNi/kg b.wt. as $NiCl_2 \cdot 6H_2O$. (Saini et al., 2013)

Fig. 4. Photograph showing fetuses with open eyelids (Oe) and club foot (Cf) at the dose of 184.5mgNi/kg b.wt.as $NiCl_2 \cdot 6H_2O$. (Saini et al., 2013)

Negative impacts on important plant processes like mineral uptake, water uptake and photosynthesis, ROS generation, impaired germination and growth activity observed in plants exposed to the toxicity of nickel (Sreekanth et al., 2013). The primary cortical neuron cells were cultured and treated with 1mM $NiCl_2$ for different duration (0, 12, 24, 48h) and against this the protective effect of potential antioxidant taurine was analysed. Results showed that taurine either reduced or altered the toxic effects of nickel chloride (Xu et al., 2015). The female rats were chosen to assess the reproductive toxicity of nickel nanoparticles on their ovaries. Results analysed were swelling of mitochondria in ovaries, missing of mitochondrial cristae, oversized endoplasmic reticulum, oxidative stress formation and the expression of certain apoptotic genes (caspase 3, 8, 9) and proteins (Fas, Cyt c, Bax and Bid) (Kong et al., 2016). The mouse fibroblast cells (L-929) were taken and cultured in 200μM Ni (II) medium for 24, 48, 72h. Inhibition of cell division, induction of cell apoptosis, altered cholesterol metabolism with up-regulation and down-regulation of some genes observed at three periods of culture (Lü et al., 2009). The nickel causes release of some cytokines and tumor necrosis factor –alpha with activation of skin cells on penetrating the skin tissues (Saito et al., 2016).

An experiment was performed to see the release of nickel from euro coins leading to a cause for allergic contact dermatitis in the palmar skin of nickel sensitized people. The experiment results were obtained after 48 and 96h and a positive result was obtained from nickel sensitive individuals (Lachapelle and Marot, 2004). An inhalation treatment of nickel carbonyl (0.06mg $NiCO_4$/l) to pregnant Syrian hamsters (on 4, 5, 6, 7 or 8 of pregnancy) was given for 15 days. On sacrificing the fetuses on 15day, it was observed that the hamsters exposed on day 4, 5, 6 and 7 showed fetus having severe malformations of eye, mouth, kidneys, ribs & lungs (Sunderma et al., 1981). The toxic effects of nickel (1.25, 2.5, 5mg/kg/day) and the protective effects of grape seed Proanthocyanidin extract (GSPE) (50 and 100 mg/kg/day) in combination with nickel (2.5mg/kg/day) was studied on the reproductive tissues of male wistar rats for 30 days. The toxic effects of nickel alone were decreased mobility of sperm, increased apoptosis in testes, increased oxidative stress generation and expression of Bax and c-Kit proteins. Reduction of these alterations were observed in rats treated with GSPE (at 100mg/kg/day) (Su et al., 2011). The body weight of some pregnant Swiss albino mice was determined and then mice were exposed to nickel [46.125, 92.25 and 184.5mg Ni/kg body weight] ($NiCl_2.6H_2O$) from 6 to 13 days of pregnancy. After observing the uteri of sacrified mice on day 18 of pregnancy, results investigated were a dose dependent decrease in body weight of pregnant mice and fetuses, decreased placental weights, decreased implant sites, various malformations of embryos like open eyelids, hydrocephaly, micropthalmia, hernia of umbilical artery, skeletal deformities, club foot, absence of hand and foot bones, abnormal rib and vertebrae formation (Saini et al., 2013).

Effect of lead on organisms

The effects of lead were observed on various organisms. Lead on contact with the body and cells can inhibit, alter or prevent various functions of the body. Lead can be harmful in even very low concentration and can have lethal effects on higher concentrations. Lead can pass from a breast-feeding mother to a new born baby through breast milk. Lead can be get collected in the bones, it can remain here for many years or may get back into the bloodstream after exiting from the bone. Serious mental and behavioural issues can arise due to poisoning by the lead (Assi et al., 2016). Blood samples from 30 lead exposed buffaloes were collected and investigated for the effect on reproduction. The animals with high blood lead concentrations revealed delay in puberty period, non-working ovaries, mastitis, presence of long-term corpus luteum, abortion, increased MDA and Nitric oxide value and decreased antioxidant values (SOD, CAT, GR, Selenium) (Ahmed et al., 2008). Lead can prove to be as toxic agent for blood, kidneys, central nervous system and gonads because it leads to increased oxidative stress on exposure to organisms (Flora et al., 2012). The IQ levels of children and its relation with blood lead concentrations (BLA) was analysed by Canfield et al., 2003 by giving exposure of lead to 172 children of different age (6, 12, 18, 24, 36, 48, 60 months) and measurement were made at 3 and 5 years of age. Result obtained revealed that with 10μg/deciliter increase of lead with associated with 4.6 point decrease in IQ. The toxicity of the lead acetate (500mg Pb/L) was measured in the kidney and liver of rats by giving them the oral dose for 8 weeks. Results investigated revealed significantly increased oxidative stress markers (MDA), liver and kidney markers (alanine aminotransferase, aspartate aminotransferase, urea, uric acid, creatinine) (Wang et al., 2012). Dose-dependent accumulation of lead analysed when rats were treated with lead (10, 50 and 200mg/kg body weight) for 3 months. Disturbed process of spermatogensis, significant reduction in germ cell population and disorganized epididymis also observed (Batra et al., 2001). In case of sterile males, there occurs an increase in cadmium and lead level in blood, seminal fluid and decrease of defense system in sperm due to cigarette smoking (Kiziler et al., 2007). A group of 172 healthy people working in zinc and lead industry were divided into two groups (lead concentration of 25-35 micro/dl and over 35micro/dl). Observations revealed significantly increased activity of ZnCu-SOD in plasma and R.B.C.s of both groups with increase in concentration of TBARS-MDA in serum (Kasperczyk et al., 2004). The lead exposed male rats (0.05 % and 0.55% lead acetate) were mated with unexposed female rats by Anjum et al., 2011. The female rats showed the formation of copulatory plugs with significant decrease in implantation, decreased weight of gonads. In males, reduced sperm count in epididymis, reduced viable sperm with low quality sperm and decreased testosterone levels noted. Decreased T3, T4 plasma levels observed when male albino rats were treated with sublethal doses of lead acetate (1/20, 1/40, 1/60 of LD50) (Ibrahim et al., 2012). The same rats were treated with same chemical (8mg/kg body weight) and sacrificed after 7, 14 and 21 days to study the kidney tissue damage. Results showed necrotic areas, vacuolated cells, cellular death in proximal convoluted tubule, reduced urinary outflow space in rats (Nisar et al., 2011).

Effect of graphite on organisms

An exposure study of 72h was performed with graphene oxide (1 and 10mg/L) on eastern oysters, *Crassostrea virginica* and effects were analyzed in vivo by using some reference organs (gills and gut gland tissues). At 10mg/L of GO, increased peroxidation of lipid found in exposed oysters, at both (1 and 10mg/L) concentrations, decreased total levels of protein in gut gland tissues with degeneration of mucous cells, hemocytic infiltration and gill vacuolation observed (Khan et al., 2019). The same organism was used for long term study of 14 days and was exposed to same compound at concentrations of 2.5 and 5mg/L of GO. Results showed alterations in the GST (glutathione-s-transferase) levels of gill tissues and glands of digestive system with increased lipid peroxidation (Khan et al., 2019). The aquatic polychaeta, *Diopatra neapolitana* was exposed to increasing concentrations (0.01, 0.10 and 1.00 mg/L) of GO for 28 days by Marchi et al., 2017.Impaired regenerative capacity, lengthened regeneration ability, cellular damage and decreased metabolic activities observed in the exposed organisms. Significant decrease in the Reactive oxygen species, rate of feeding and number of new born observed when the freshwater flea, *Ceriodaphnia dubia* given chronic exposure of sublethal concentration of GO (Souza et al., 2018). A combination experiment of GO with trace elements (Cadmium and Zinc) was done on shrimp *Palaemon pandaliformis.* No acute toxic effects observed for GO alone at 5mg/L after 96h. Increased toxicity was observed in combination with Cadmium and Zinc (Melo et al., 2019). The BF-2 cells of Bluegill sunfish on exposure to different concentrations of GO (0, 10, 20, 40, 60, 80 and 100 µg/mL) for 24h revealed dose and time-dependent cytotoxicity by showing increased levels of SOD, CAT, ROS, lipid peroxidation and 8-hydroxy-2-deoxyguanosine and decreased glutathione levels when treated with GO (Srikanth et al., 2017). Elevated levels of SOD, CAT, GST, lipid peroxide collection total R.B.C.s, haemogloblin, W.B.Cs, decreased level of reduced glutathione noted specifically in the mitochondria and increased protein in liver of climbing perch (*Anabas testudineus*) when exposed to sublethal concentrations of GO (Paital et al., 2019). The effects of GO of 1mg/L and perfluorooctanesulfonate (PFOS) of 500ng/L were observed in the blood, liver, kidney, intestines, muscles and gills of three-month-old common carp (*Cyprinus carpio*) for 28 days. The increased accumulation of PFOS due to GO observed in some organs (kidney, intestine and liver), indicating that GO assistance to PFOS in passage across the tissues (Qiang et al., 2016).

The damage caused due to high concentration of GO and CXYZ (carboxyl graphene) nanoplatelet, was observed in the plasma membrane of Human hepatoma cell line (HepG2), with the generation of oxidative stress and phagocytosis of graphene derivatives by the non-phagocytotic cells (HepG2) (Lammel et al., 2013). Increased oxidative stress activities (increased SOD, CAT, MDA) and decreased Glutathione (GSH) observed in liver of two-month-old zebrafish when exposed to different doses (1, 5, 10 and 50mg/L) of GO for 14days. Increased transcription of Interleukin-6 (il-6), interleukin- 1B (il-B) and tumor necrosis factor-alpha (tnf-alpha) noticed with disintegration of cell boundaries, vacuolation, histolysis and loose arrangement of cells of liver and intestine (Chen et al., 2016). The 1-2 celled stage embryos of zebrafish showed morphological defects like shortened body, edema of pericardium, curved spine, underdevelopment of brain and retina, less consumption of yolk and disrupted circulation when microinjected with different doses (250, 500, 750pg/embryo, which is <1ng) (lateral size 100-200nm, height 1-1.5nm) of nanographene oxide (NGO) (Jeong et al., 2015). The microinjection of Graphene oxide (GO)[average area distribution 40-60nm, thickness 1-3nm] or Multi-Functional Graphene (MFG) [40-60nmsize, thickness ~4-6nm] was given to one to four cell zebrafish embryos (wild type AB strain) at the volume of 10nL and concentrations 0.05-0.1ng/nL into the polar region for the evaluation of toxicity at 76 hpf. Morphological irregularities observed were yolk sac edema, cardiac abnormality, tail or spinal cord flexure (Golllavelli and Ling, 2012).

Effect of silver on organisms

The silver ions present in the solution can block the Na^+ /K^+ ATPase thus affecting the ionoregulation of Na^+ Cl^- ions across the gills by travelling to the branchial epithelial cells and basolateral membrane of the gill (Bury and wood, 1999). The effects of silver nanoparticles (63, 129,300 µg/L) and silver nitrate (39 and 386 µg/L) were analyzed by Bilberg et al. (2010) on the oxygen carrying ability of the fish, *Perca fluviatilis*. The fish showed difficulty in breathing due to the deposition of nanosilver on the gills surface, leading to condition of hypoxia. The effects of silver nanoparticles for its antimicrobial activity were observed on E. *coli* (a gram-negative bacteria). The bacteria showed pit formation in the cell wall with cellular damage and collection of nanoparticles in the membrane of bacterial cell (Sondi and Salopek-Sondi, 2004). Silver nanoparticles (average size 14±6nm), silver chloride colloid (average size 25µm) and silver ions (silver nitrate) were used by Choi et al., 2008 to assess the microbial growth of waste water treatment plant flora at a concentration of 1mg/L Ag. Results revealed negative impact on growth of nitrifying bacteria by the use of silver nanoparticles along with pit formation in the cell wall of bacteria. Two tropical microalgae species, freshwater *Scenedesmus* sps. and marine diatom *Thalassiosira* sps. were observed for the toxic effects of AGNPs. Higher toxicity of AGNP was observed in freshwater microalgae which showed changes in cell diameter, increased total lipid production and lowered chlorophyll a content (Pham, 2019).

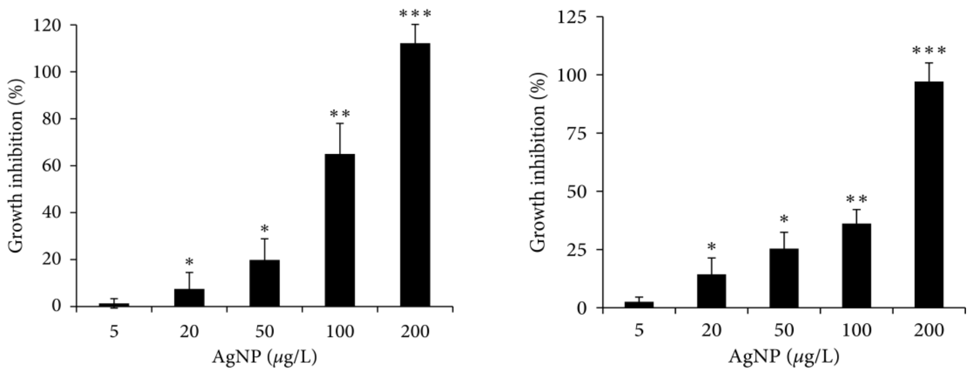

Fig. 5. Effect of silver nanoparticles on growth of (a) *Scenedesmus* sp. and (b) *Thalassiosira* sp. Asterisks show significant differences compared with the control. (*P<0.05, **P<0.01, ***P<0.001) (Pham, 2019).

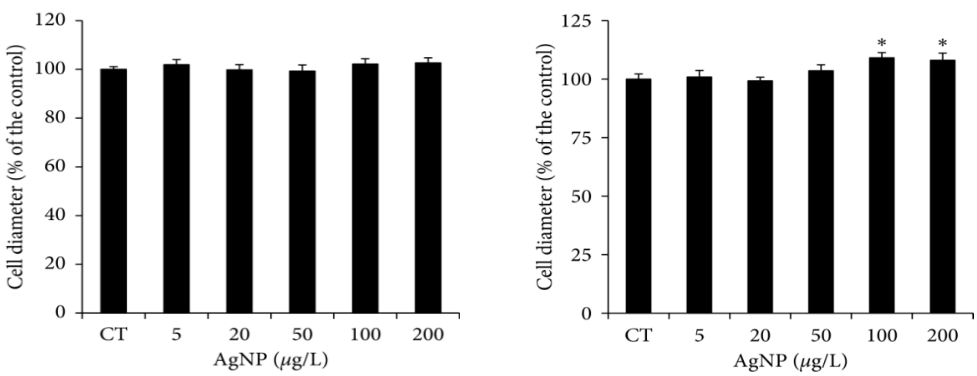

Fig. 6. Algal cell diameter (µm) of (a) *Scenedesmus* sp. and (b) *Thalassiosira* sp. upon exposure to silver nanoparticles. Asterisks indicate significant differences compared with the control (*P<0.05) (Pham, 2019).

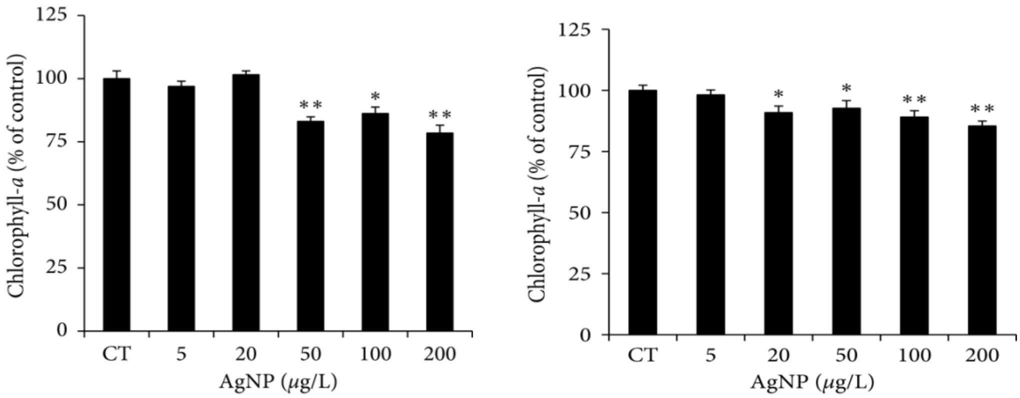

Fig. 7. Chlorophyll-a content of (a) *Scenedesmus* sp. and (b) *Thalassiosira* sp. upon exposure to silver nanoparticles. Asterisks indicate significant differences compared with the control (*P<0.05, **P<0.01) (Pham, 2019).

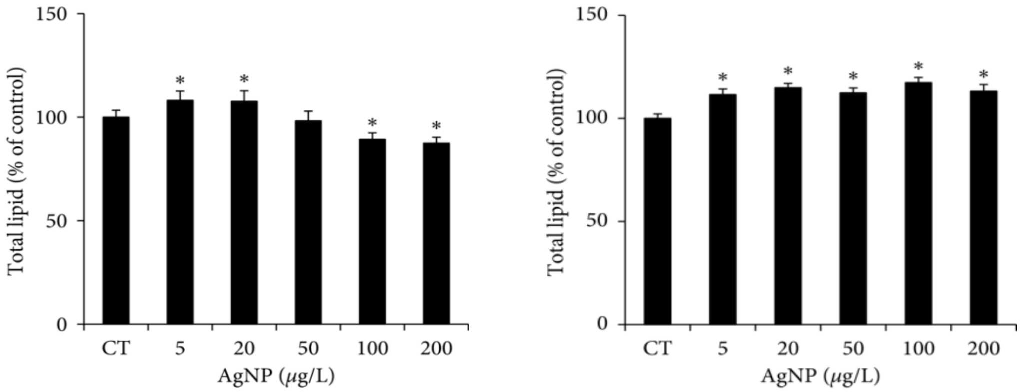

Fig. 8. Total lipid content of (a) *Scenedesmus* sp. and (b) *Thalassiosira* sp. upon exposure to silver nanoparticles. Asterisks indicate significant differences compared with the control. (*P<0.05) (Pham, 2019).

The silver nanoparticles and silver nitrate mixed in water (artificial pond water and artificial pond water with removed calcium chloride) were given to freshwater snail *Physa acuta* by Gonçalve et al. (2017) and acute and chronic toxic effects were observed in the snail. After 96h (acute toxicity), decrease length of shell in juveniles observed more than in adults due to AgNPs and $AgNO_3$; reduced rate of hatching due to silver ions observed in chronic exposure. The morphological and cyto-nuclear changes were observed in two gram strains of bacteria- E*. coli* (gram negative) and *Staphylococcus aureus* (gram positive) after the treatment with silver nitrate. Loss of replication ability of DNA, inactivation of protein, deposition of electron dense granules inside cells of bacteria or in the surrounding of cell wall observed (Feng et al., 2000). The toxic effects of silver nanoparticles due to long term exposure were analyzed in humans by Panyala et al. (2008). The result investigated were a condition of permanent color change of skin to bluish-grey (argyria) and of eyes (argyrosis), eye irritation, skin irritation, digestive tract and respiratory tract irritation, blood cell changes along with liver or renal damage. At higher concentrations (>44µgm/l) Ag nanoparticles can cause necrosis to cells thus causing cell membrane rupture rapidly (Gopinath et al., 2008). The silver particles are observed to accumulate in the neurons and glia cells when these cells are exposed to different silver compounds like silver lactate, silver nitrate and silver proteins. CNS showed toxic effects such as cerebral ataxia (Aaseth et al., 1981). The six-days old mouse testes were taken as a study material by Braydich-Stolle et al. (2005) and C18-4 germ line stem cells from type A spermatogonia was used to study the effects of different nanoparticles (Silver= 15nm, Molybednum= 30nm, Aluminium =30nm and cadmium=1000nm). Significant changes seen due to silver nanoparticles at 10µg/ml and above concentrations with some necrotic areas and apoptosis; at 5-10 µg/ml concentration, significantly reduced function of mitochondria with decreased viability of cell observed.

Effects of lithium on organisms

The embryos of medaka (*Oryzias latipes*) were treated with 1mg/L of lithium and were assessed for the developmental toxicity and teratogenicity of lithium with the effects on molecular mechanisms using a nano-second pulsed electric field (nsPEF) technique. Results observed were delay in the development of embryos with the deformation of heart, eyes, blood vessels, head, hyperemic edema, hypertrophy of heart, retardation of embryonal growth with changes in the gene expression of embryos (Tominaga et al., 2019). The lengthened period of circadian rhythm in marine unicellular organism *Skeletonema costatum* (Greville) was observed by Østgaard et al. (1982) due to exposure of lithium at a concentration of 0.5-1.5mM of lithium ions (Li^{+}) with growth inhibition at a concentration greater than 2mM of lithium. The specimens of mussel, *Mytilus galloprovincialis* from the Aveiro coastal lagoon and divided them into control group (uncontaminated sea water) and exposed group (contaminated with different concentrations of lithium (100, 250 and 750 µg/L) for 28 days. Results demonstrated that with increase in lithium concentrations, the lithium accumulation in the body of mussels also increased causing decreased basal metabolic rate. At concentration of 750µg/L, loss of homeostasis with increased lipid peroxidation (oxidative stress) and neurotoxic activity leading to decreased Ach enzyme activity also observed in exposed group (Viana et al., 2020).

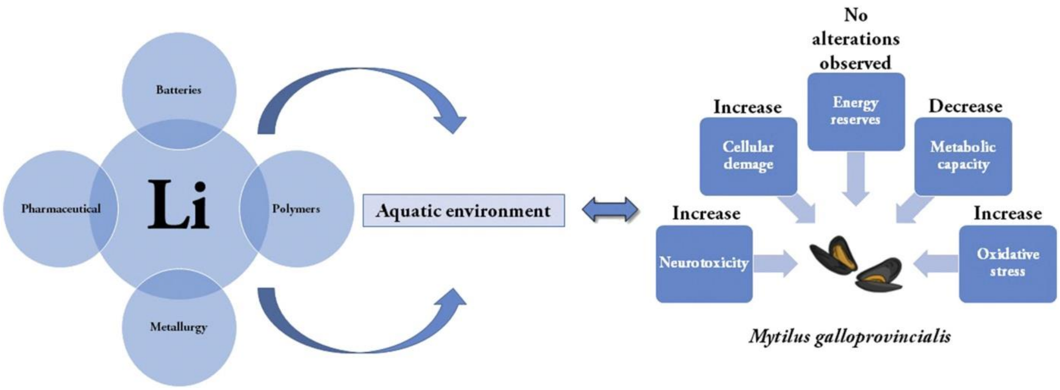

Fig. 9. The effect of lithium on *Mytilus galloprovincialis* (Viana et al., 2020).

Changes in food finding behavior and antioxidant activity were observed in gastropod, *Tritia neritea* when exposed to 0.56mg/L of lithium and warm temperatures. Result showed start of oxidative stress, overproduction of ROS and decreased foraging activity and activeness in searching for the food (Rodríguez et al., 2021). The higher concentrations (~280 & 416mg/L) of lithium caused the inhibition of animal-vegetal axis development, abnormal eye position, abnormal anterior midline structures, inhibition of tissue development mainly ectodermal tissues (Crawford, 2003). The embryos of polychaeta, *Ophryotrocha labronica* were exposed to high and moderate concentrations of lithium chloride. Results observed were inhibited development of embryos at high concentration (50% of ~3900 mg/L), formation of abnormal embryos after 4 days treatment of highest concentration. At moderate concentration, premature rupture of yolk granule membrane, malformed embryos and loss of DNA content of the cells observed (Emanuelsson, 1971). Evagination of amniotic cavity of individuals with incomplete adult rudiment that did not convert into juvenile and abnormal gastrulation observed when sea urchin *Peronella japonica* was exposed to ~140mg/L of lithium (Kitazawa and Amemiya, 1997). Altered mitochondrial activity (suppressed oxygen consumption leading to reduced respiration and oxidative phosphorylation) observed when the blastula of *Paracentrotus lividus* was induced for vegetalization at a concentration of ~515mg/L of lithium (Wolcott, 1982). An experiment by collecting eggs from adult sea urchins, *Paracentrotus lividus* during their breeding season was performed and then treated the eggs with Lithium chloride (LiCl) 10 minutes prior to fertilisation and 10 minutes after fertilisation at concentrations of 1, 2, 3, 4, 5, 10, 80 mM and observed the results after 48h of incubation period and at 1 week after fertilisation for the control and treated eggs. Results found that more abnormal embryos were formed from the eggs treated with lithium chloride before fertilisation at concentrations from 1- 10mM while the abnormal embryos were formed only at 5 & 10mM with eggs treated after fertilisation. Abnormalities found at pluteus stage were abnormal arms, abnormal apex having cross- shaped or disjointed spicules, broader arms. At the next stage, malformed body with pyramid shape and not well degraded and retracted arms were observed. Imbalance of gene expression (overexpression and less expression) also noted at different developmental stages (Ruocco et al., 2016).

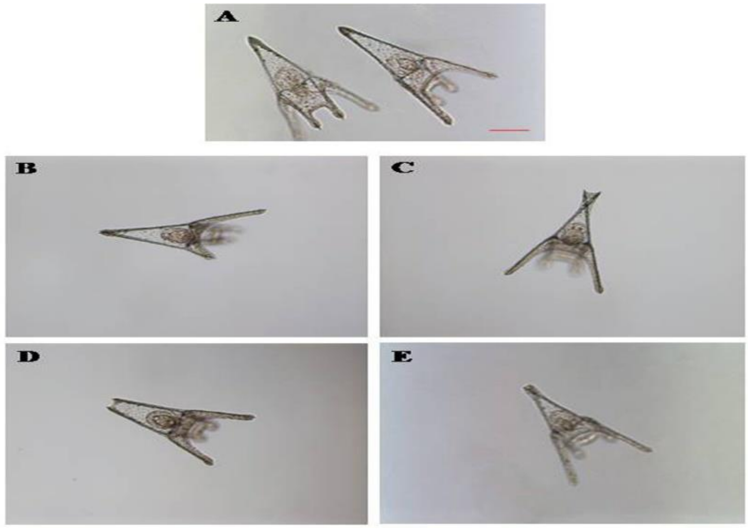

Fig. 10. Malformations induced by LiCl (Ruocco et al., 2016). Examples of malformations induced in (**B**–**E**) *Paracentrotus lividus* plutei treated with LiCl from 1.0 to 10 mM and observed at 48 hpf in comparison with (**A**) embryos in sea water without LiCl.

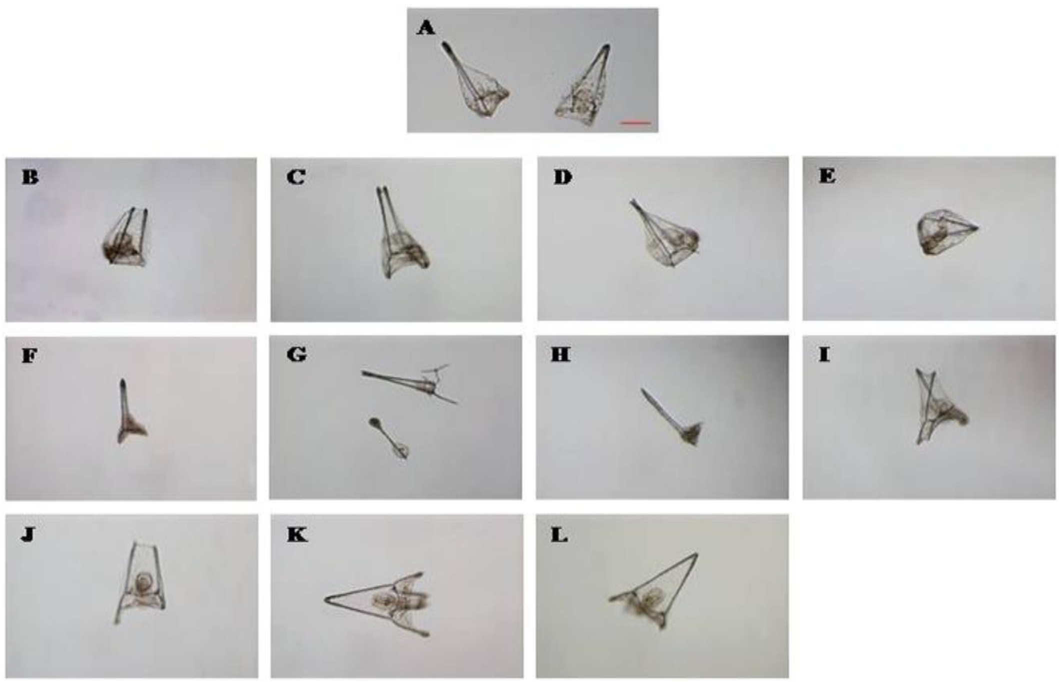

Fig. 11. Malformations in sea urchin embryos at one week after fertilization (Ruocco et al., 2016). Examples of malformed embryos induced in P. *lividus* embryos at one week of incubation with LiCl 5 and 10 mM (**B**–**L**), in comparison with control embryos in sea water without LiCl (**A**).

Three separate exposures of 1mg Li/L were given to juveniles of rainbow trout (*Oncorhynchus mykiss)* and the concentration and effects of lithium ions was observed in its brain and plasma. Results observed were increased levels of archidonic acid in plasma after 48h with accumulation of lithium in brain and plasma of juvenile fishes. Changes were also observed in some enzymes (prostaglandin synthase inhibition, enhanced expression of copper transporting ATP synthases and Na+/K+ ATPase (Tkatcheva et al., 2015). Significant changes in the glomerulus with injured renal cell lining noted when the rats were given doses of lithium on alternate days for 7 weeks. Human cardiomyocyte cell line, AC 16 was assessed for the effect of lithium (LiCl and Li_2SO_4) at different concentrations (0mmol/L, 0.2mmol/L, 1mmol/L, 2.5mmol/L, 12.5mmol/L and 25mmol/L) for 48h. Significant reduction in growth of AC 16 cells noticed at 5mmol/L & 25mmol/L of LiCl and decreased viability of AC 16 cells noticed at 2.5 and 12.5mmol/L of $LiSO_4$. Significant reduction of expression of PCNA (Proliferating cell nuclear antigen) noted after 48h treatment with 5 or 2.5mmol/L of LiCl or Li_2SO_4. Significant increase in AC 16 cell apoptosis observed on exposure of 5mmol/L of LiCl and Li_2SO_4 after 48h due to increased expression of apoptosis marker, TP53 gene and decreased expression of cell proliferation marker (cyclin E) in these cells (Shen et al., 2020).

Effect of carbon black on organisms

The toxic effects of carbon black (Printex 90) on genetic material of mice were analyzed by giving intratracheal instillation. Results obtained were increased level of DNA strand break in bronchoalveolar lavage cells (BALC) and lung tissues of the mice with increased frequency of mutation and cytogenetic end points (Ianni et al., 2022). Pregnant mice (C57BLI6BomTac) were exposed to 42mg/m^3 of Printex 90 (carbon black) through inhalation on different gestational days (7, 10, 15, 18) for 1h/day with total doses of 11, 54, 268µg/animal. Results revealed continuous inflammation of lung in exposed mother after 3-5 days of exposure with more strand breakage of DNA in liver of mother and offsprings (Jackson et al., 2011).Suspension of carbon black nanoparticles (95µg/kg body weight) was given to Pregnant ICR mice through the nasal tract during different gestational phases- Pre-implantation phase (Day 4& 5), organ formation phase (Day 8 & 9) and fetal development phase (Day 15 & 16) and the organs (spleen and thymus) were obtained from the offspring on Day 1, 3 and 5 after delivery. Results showed that the total no. of splenic cells and non- T/non-B lymphocytes in offspring on Day 5 were significantly higher after the mice are exposed to CBNP during the organ formation period (Onoda et al., 2021). Another time mated mice were intratracheally exposed to Printex 90 dispersed in Millipore water on gestational days (7, 10, 15 & 18) with total doses of 11, 54, 268µg Printex 90/animal to study the toxicological effects. Results showed induced persistent lung inflammation (Jackson et al., 2011). C57BL/6 mice were given exposure of CBNPs intratracheally that induced neutrophil influx in mice after 4h of exposure with quick appearance of cell damage indicator in BALF (bronchoalveolar lavage fluid) at 30 minutes. Necrotic features were observed in macrophages showing lysosomal rupture, cathepsin B release, ROS generation, decreased ATP level in the cell and leakage of mitochondrial DNA from the necrotic cells that activated neutrophils and started severe inflammation (Yuan et al., 2020).

Effect of polypropylene on organisms

Microplastics are highly toxic (Singh, 2022; Gupta et al., 2022). *Daphnia* is a model animal for assessing microplastic toxicity (Kaur et al., 2022). *Daphnia similis* was given acute exposure of polypropylene microplastic. It accumulated the microplastic in its digestive tract. Results obtained were increased production of ROS, mobilizationon of animal, increase in antioxidant enzymes (SOD, CAT, GPx & GST), non-antioxidant enzyme (reduced glutathione, GSH) and lipid peroxidation and carbonyl protein production due to formation of free radicals and decreased neurotransmitter enzyme level in *Daphnia similis* (Jeyavani et al., 2021).The marine zooplankton *Atremia salina*, at different life stages was treated with spherical polypropylene microplastics of size ~11.86µm-44.62µm and was assessed for its toxicity at different concentrations (1, 25, 50, 75, 100µg/mL) within 48h. Polypropylene microplastic accumulated in the gut of the organism and changes were observed in the homeostasis, increased oxidative stress in nauplii leading to death at LC_{50} of 40.947µg/mL, metanauplii death at LC_{50} of 51.954µg/mL. The juvenile stage revealed changed behaviour, imbalanced antioxidant biomarkers (SOD, CAT, GSH, GST), damaged epithelial cells and reduced Acetylcholinesterase enzyme activity (Jeyavani et al., 2022).

Effect of silicon on organisms

In a study, the heifers of red steppe breed cattle were given silicon dioxide nanoparticles during the process of reproduction to analyse the effects on fertility. Results found were increased fertility and increased progesterone levels in the heifers treated with silver dioxide nanoparticles (Khristianovskii et al., 2019). Young adult beagle dogs and young rats, male as well as female, were given oral preparations made from several forms of silicon for one month, after this the blood and urine sample were investigated by sacrificing the treated dogs and rats. Histopathological studies revealed polydipsia, polyuria and soft tools in some of the animals treated with sodium silicate and magnesium trisilicate, renal lesions noticed in dogs treated with the same compounds, no lesions appeared in rats (Newberne and Wilson, 1970).

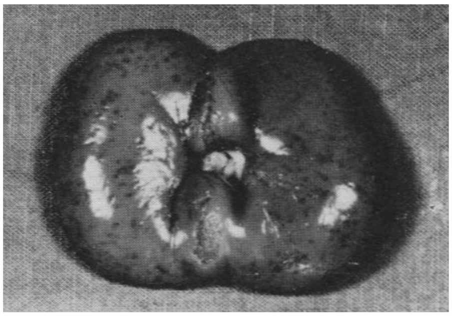

Fig. 12. Gross lesions of kidney typical of those observed in dogs fed sodium silicate or magnesium trisilicate (Newberne and Wilson, 1970).

Conclusion

The E- vehicles can save fossil fuel burning and prevent the pollution but the amount of energy these vehicles use during their manufacturing process is high enough. The chemicals used in their batteries have proven to be detrimental for the health of organisms and the environment on their release into the surroundings. In order to use these vehicles and get the proper benefit from them, one should work on finding non-toxic alternative chemicals for their batteries. Further studies are recommended so as to develop efficient methods for easy and safe recycling of e-vehicle batteries.

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The author declares no competing interests.

Ethics approval
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