Journal of Chemical, Biological and Physical Sciences

An International Peer Review E-3 Journal of Sciences

*Available online at*www.jcbsc.org

Section D: Environmental Science

CODEN (USA): JCBPAT Research Article

E-Waste Supervision – Need of the Hour

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Received: 20 August 2014; **Revised:** 08 September 2014; **Accepted:** 14 September 2014

Abstract: 'e-waste' can be defined as electronic equipment's / products, Waste from Electronic and Electrical Equipment, which have become obsolete due to advancement in technology, changes in fashion, style and status nearing the end of their useful life. Innovative changes that followed the advances in information technology during the last three decades have radically changed people's lifestyle. The changing standard of living due to urbanization, globalization and population explosion, has led to increased consumption of electronic products. The ever increasing production and use of electronic products compounded by dumping from developed countries creates the serious problem of e-waste disposal that may create crises of unmanageable proportions. E-Waste contains nearly over 1,000 different substances and chemicals, many of which are toxic enough to create serious problems for the environment and human health, if not handled properly. The problem is faced by many regions across the globe. Dumping of electronic instruments like discarded computers, televisions, VCRs, stereos, copiers, fax machines, electric lamps, cell phones, audio equipment and batteries can leach hazardous materials such as lead, mercury into the soil and groundwater. People burn e-waste in the open atmosphere releases large amounts of mercury and lead into the air. Uncontrolled burning causes environmental and health problems to those directly involved. Many of these products can be reused, refurbished or recycled in an environmentally safe manner so that they are less harmful to the ecosystem. The paper highlights e-waste scenario, classification, health hazards, current management practices, role of different stakeholders and their interventions in sustainable e-waste management in India.

Keywords: e-waste, environment, management, groundwater and atmosphere

INTRODUCTION

Electronics things are changing the lives of people everywhere. They are touching every aspect of our lives – the way we do business and communicate with the people. Although this development has helped to enhance the quality of our life, at the same time due to the mismanagement of e-waste disposal has led to new problems to the environment. The electronic industry thrives on new generation products. Consumers are drawn to the latest products like cellular phones, stereos, air conditioners, computers, etc. e-Waste contains certain components such as chlorinated and brominated substances, toxic gases, toxic metals, acids, plastics and plastic additives, which are highly toxic. The hazardous content of these materials pose an environmental and health hazards. Rapid obsolescence of electronic goods, compounded by dumping from developed countries, has heightened the e-waste problem in India to the brink of spilling over into an acute crisis. Discarded e-waste is the fastest growing stream of waste in industrialized countries[1-5].

E-Waste is emerging as a risk to society due to the escalating sales and rapid obsolescence of the electronic products. Several e-waste processing units adopt very primitive recovery mechanism involving potential environmental and health hazards. It is a matter of great concern at both state and national levels, that such wastes may pose severe threat to the environment, if they are not managed properly. Hence the problem of e-waste needs urgent global attention [6-8].

E-WASTE- AN INITIATION

e- Waste has been defined in various ways. Some of them are as follows.

a) Electronic waste, popularly known as ‘e-waste’ can be defined as electronic equipments / products, which have become obsolete due to advancement in technology, changes in fashion, style and status or outlived their life.

b) e-Waste is the term used to describe old, end-of-life electronic appliances such as computers, laptops, TVs, DVD players, mobile phones, mp3 players, etc. which have been disposed of by the users.

c) E-Waste is a popular, informal name for electronic products nearing the end of their "useful life".

SOURCES OF THE E-WASTE

a) Individuals and Small Business houses: The useful span of a computer has come down to less than two years due to improved versions being launched about every 18 months. Often, new software is incompatible or insufficient with older hardware so that customers are forced to buy new computers.

b) Large corporations, institutions and government organizations: Large users upgrade employee computers regularly.

c) Original equipment manufacturers (OEMs): OEMs generate e-waste when units coming off the production line don’t meet the quality standards and disposed off.

CLASSIFICATION OF E-WASTE

E-waste encompasses ever-growing range of obsolete electronic devices. These are classified into different categories by Waste Electrical and Electronic Equipment Directive (WEEED).

a) Large household appliances (ovens, refrigerators etc.)
b) Small household appliances (toasters, vacuum cleaners etc.)
c) Office & communication (PCs, printers, phones, faxes etc.)
d) Entertainment electronics (TVs, portable CD players etc.)
e) Lighting equipment (mainly fluorescent tubes)
f) E-tools (drilling machines, electric lawnmowers etc.)
g) Sports & leisure equipment (electronic toys, training machines etc.)
h) Medical appliances and instruments
i) Surveillance equipment
j) Automatic issuing systems (ticket issuing machines etc.)

Problems caused by e-waste: e-Waste contains over 1,000 different substances and chemicals, many of which are toxic and are likely to create serious problems for the environment and human health if not properly handled. However, classification of e-waste as hazardous, or otherwise, depends on the amount of hazardous constituents present in it. E-Waste contains many toxics compounds such as heavy metals, including lead, copper, zinc, aluminum, flame retardants, plastic casings etc[9-11].

The EPA estimates the following short life spans for these products.4

- ✓ Desktop computer: 2 – 4 years
- ✓ Laptop computer: 2–3 years
- ✓ Cell phone: 1–3 years
- ✓ Television: 7–13 years for a television

Although new technology has made it more affordable to replace electronic devices instead of repairing them, the question remains as to what should be done with the growing number of electronic items (computers and computer peripherals, televisions, stereos, DVD players and VCRs, video game consoles, digital cameras and camcorders, cell phones, and more) that are quickly making their way from store shelves into landfills at an alarming and accelerating rate[12,].

Toxic components present in e- waste are classified as follows

- ➢ Elements in bulk - lead, tin, copper, silicon, carbon, iron and aluminum
- ➢ Elements in small amounts -zinc, chromium, cadmium and mercury
- ➢ Elements in trace amounts - germanium, gallium, barium, nickel, vanadium, beryllium, gold, titanium, ruthenium, cobalt, palladium, manganese, silver, antimony, bismuth, selenium, platinum, arsenic, lithium, boron, etc

Devices containing above elements

- ✓ Lead: Solder, CRT Monitors (Lead in glass) and Lead-acid battery
- ✓ Tin: Solder
- ✓ Copper: Copper wire and printed circuit board tracks
- ✓ Aluminum: Nearly all electronic goods
- ✓ Iron: Steel chassis, cases & fixings
- ✓ Silicon: Glass, transistors, Ics and Printed circuit boards.
- ✓ Nickel & cadmium: Nickel-cadmium rechargeable batteries
- ✓ Lithium: Lithium-ion battery

- ✓ Zinc: Plating for steel parts
- ✓ Mercury: Fluorescent tubes and tilt switches (pinball games, mechanical doorbells)
- ✓ Sulphur: Lead-acid battery
- ✓ Carbon: Steel, plastics and resistors.

Disposal of e-wastes is a particular problem faced in many regions across the globe. E-Wastes that are landfilled produces contaminated leachates which eventually pollute the groundwater[2]. Improperly monitored landfills can cause environmental hazards. Mercury will leach when certain electronic devices, such as circuit breakers are destroyed. The same is true for polychlorinated biphenyls (PCBs) from condensers. When brominated flame retardant plastic or cadmium containing plastics are land filled, both polybrominated diphenyl ethers (PBDE) and cadmium may leach into the soil and groundwater. Acids and sludge obtained from melting computer chips, if disposed on the ground causes acidification of soil. All the industrial areas are facing acute potable water shortage, due to disposal of recycling wastes such as acids, sludges etc. in rivers. In addition, uncontrolled fires may occur frequently at landfills. When exposed to fire, metals and other chemical substances, such as the extremely toxic dioxins and furans can be emitted from halogenated flame retardant products and PCB containing condensers. The most dangerous form of burning e-waste is the open-air burning of plastics containing metals in order to recover copper and other metals. The toxic fall-out from open air burning affects both the local environment and broader global air currents, depositing highly toxic by products in many places throughout the world. Incineration of e-wastes can emit toxic fumes and gases, thereby polluting the surrounding air. **Table 1** summarizes the health effects of certain constituents in e-wastes[13].

Indian Scenarios on e-Waste: India's rate of e-waste is growing phenomenally. The concentration of plastics, metals and glass increased from 1.5% in 1971 to 8.0 % in 2000 in the municipal solid waste. The total waste generated by obsolete or broken-down electronic and electrical equipment in India has been estimated to be 1, 46,180 tons per year. In India, the e-waste problem seems to be compounding due to rapid changes taking place not only in computers and cell phones but also in domestic appliances such as washing machines, refrigerators, microwave ovens, TVs, etc. E-Waste of developed countries dump their wastes in India and other Asian countries legally and illegally. Major reasons are cheap labour and lack of environmental and occupational standards in Asian countries. Thus the toxic effluent of the developed nations would flood the world's poor nations. Poorly-protected workers dismantle the e-waste, often by hand, in appalling conditions. Uncontrolled burning, disassembly, and disposal are causing environmental and health problems, including occupational safety and health hazards among those directly involved, due to unscientific methods of processing the waste. About 25,000 workers are employed at scrap yard in Delhi alone. Other e-waste scrap-yards exist in Meerut, Ferozabad, Chennai, Bangalore and Mumbai. Majority of Municipal Corporation's burn e-waste in the open air along with garbage, releasing large amounts of mercury and lead into the atmosphere. Currently there are no regulations to manage the e-waste nor any scientifically designed facilities for the e-waste collection, treatment, recycling, reuse and final disposal.

A great stress is laid on preservation and protection of the environment so that it can pass as a valuable resource from generation to generation. Management of e-waste should begin at the point of generation. This can be done by waste minimization techniques and by sustainable product design. So far e-waste is not a subject for academic discussions at environmental forums. There is a growing realization that the issue may assume dangerous proportions over the next few years if it is left un-addressed. To remedy the ever-growing e-waste problem, India needs to have strong rules and regulations, specific to e-waste disposal. Due to the lack of statuary regulations on e-waste standards

for disposal and mechanism for handling these toxic e-waste products, they end up in landfills or partly recycled in an unhygienic conditions and partly thrown into waste streams. Recently a national working group headed by the Chairman, Central Pollution Control Board (CPCB) was formed to identify, plan and implement the recommendations related to e-waste handling and management in India. E-Parisaraa, an eco-friendly recycling unit, which is located in Dobaspet industrial area, about 45 km north of Bangalore, makes full use of e-waste. The plant, which is India's first scientific e-waste recycling unit will reduce pollution, landfill waste and recover valuable metals, plastics & glass from e-waste in an eco-friendly manner.

E-WASTE DISPOSAL METHODS

Incineration: Incineration is one of the disposal practices that helps to reduce the amount of landfill space needed. This process releases heavy metals such as lead, cadmium, and mercury into the atmosphere and which can bioaccumulate in the food chain, particularly in fish, which is the major source of exposure for the general public. The advantages and disadvantages of incineration are

Advantages:

a) Requires minimum land
b) Can be operated in any weather
c) Produces stable odor-free residue
d) Refuse volume is reduced (volume by 90% and weight up to 75%)

Disadvantages:

a) Expensive to build and operate
b) Requires high energy
c) Require skilled personnel and continuous maintenance

Recycling: Environmental Protection Agency (EPA) has ranked the recycling method as the most environmentally safe strategy. Electronics recycling is an emerging industry that is at a critical stage of development, in terms of growth and challenges. Without protective measures, recycling e-waste can led to severe health and environmental hazards. Even though the recycling operation is covered under various labour and industrial laws in India, most of them are not implemented in the 'informal' sector. E-Waste recycling in developing countries has become a lucrative business. Recycling process provides a livable environment for the future however the process is expensive and in some cases the waste cannot be recycled. The summarized futures of recycling are reported in **Fig.1.**

Landfill: Land filling of e-waste is one of the most widely used methods of disposal and is prone to hazards because of leachate[4]. Older landfill sites and uncontrolled dumps pose a much greater danger of releasing hazardous emissions. Mercury, Cadmium and Lead are among the most toxic leachates. Mercury will leach when certain electronic devices such as circuit breakers are destroyed. Lead has been found to leach from broken lead-containing glass, such as the cone glass of cathode ray tubes from TVs and monitors. When brominated flame retarded plastics or plastics containing cadmium are land filled, both PBDE and cadmium may leach into soil and groundwater. In addition, landfills are also prone to uncontrolled fires, which can release toxic fumes. The design of modern scientific landfill is shown in **Fig.2**. According to the US EPA, more than 4.6 million tons of e-Waste ended up in landfills in 2009. Toxic chemicals in electronics products can leach into the land over time or be released into the atmosphere, impacting nearby communities and the environment.

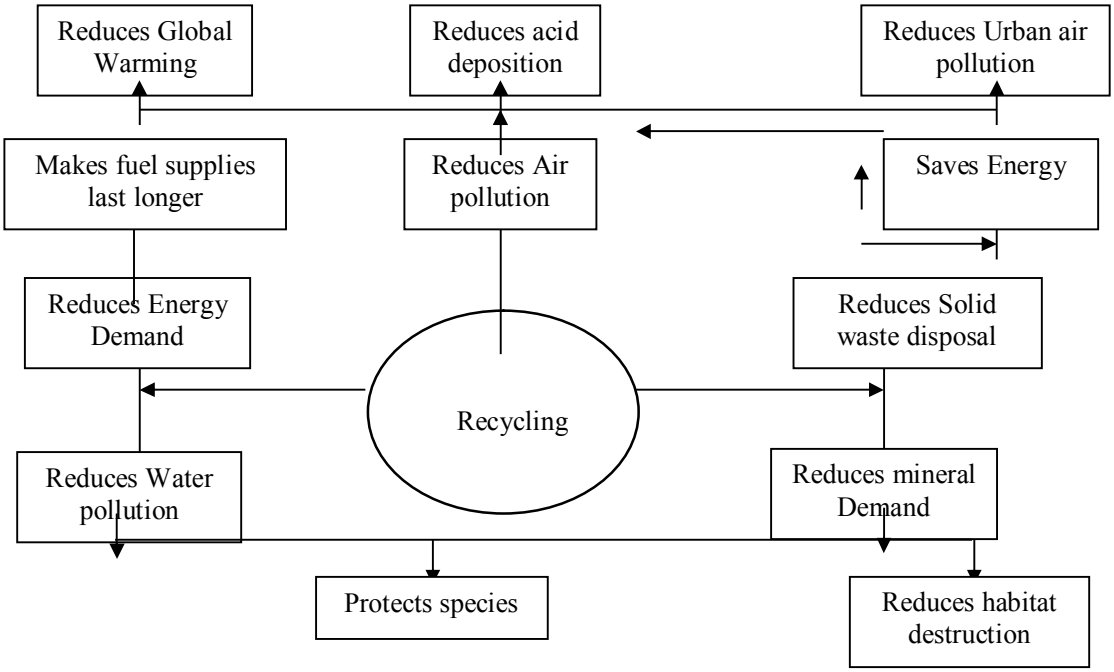


Fig.1 Recycling

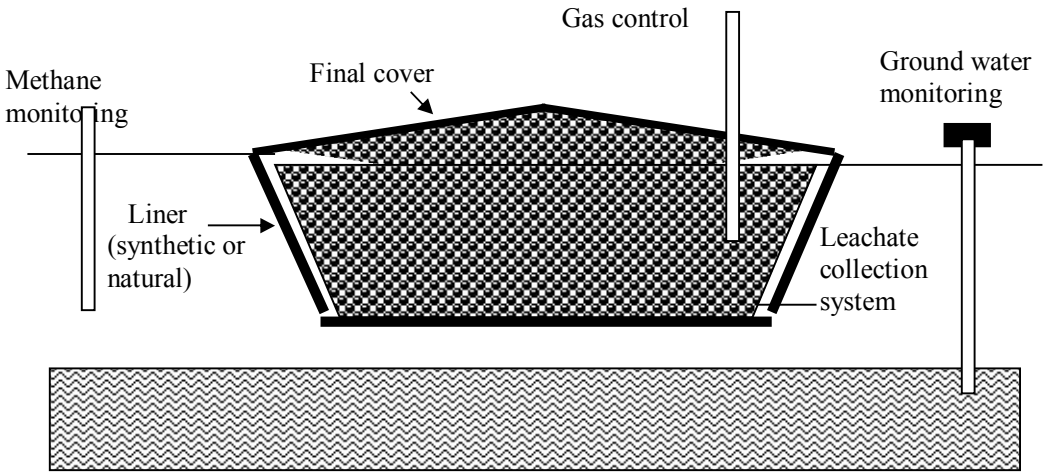


Fig.2 Design Components in a modern land fill

Reuse: This is a good way to increase a product's lifespan. Many old products are exported to developing counties. Although the benefits of reusing electronics in this way are clear, the practice is causing serious problems because the old products are dumped after a short period of use in areas that are unlikely to have hazardous waste facilities

Export: e-Waste is routinely exported by developed countries, often in violation of the international law. Inspections of 18 European seaports in 2005 found that as much as 47 percent of waste destined for export, including e-Waste, was illegal. At least 23,000 metric tons of undeclared or "grey" market electronic waste was illegally shipped in 2003 to the Far East, India, Africa, and China. In the USA, it is estimated that 50–80 percent of the waste collected for recycling is being exported in this way. This practice is legal because the USA has not ratified the Basel Convention. (Source: Greenpeace International)

Management of e-Waste: The mantra of "Reduce, Reuse, and Recycle" applies here. Reduce your generation of e-waste through smart procurement and good maintenance. Reuse still functioning electronic equipment by donating or selling it to someone who can still use it. Recycle those components that cannot be repaired[5].

The hierarchy of waste management[6] is shown in **Fig. 3.**

- Avoid – Use of non-hazardous material in place of hazardous material, ex:- replace the conventional plastics with biodegradable plastics
- Minimize (reduction) – Use less quantity. Changes can be made in the production process, i) Improved operating and maintenance procedures, ii) Material change and iii) Process-equipment modification.
- Recycle - Recycle those components that are recyclable – plastics, glass and metals
- Treat – Convert the hazardous substance to less hazardous
- Dispose – Dispose scientifically

Government's responsibilities

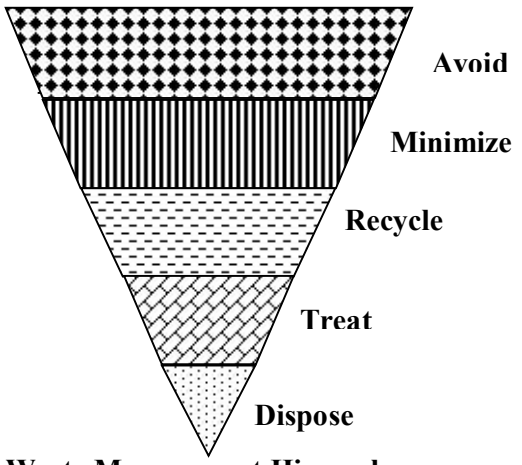
- Formulation of e-waste policy and legislation
- Encourage scientific recycling
- Imposing tax for the disposal of toxic materials on manufacturers/consumers
- Subsidize recycling and disposal industries
- Incentive schemes for e-waste collectors
- Awareness programmers on e-waste management
- Developing of environmentally sound recycling facilities
- Control on import of e-waste coming in the country in the name of Donations/Charity

Responsibility and role of Industry

- Generators of e-wastes should take responsibility to determine the output characteristics of wastes and if hazardous, should provide management options.
- Use of biodegradable materials for production of electronic components and peripherals.
- Utilize technology sharing particularly for manufacturing and de manufacturing.
- Manufacturers, distributors, and retailers should undertake the responsibility of recycling/disposal of their own products.
- Asset Recovery Services (ARS) is a suite of services that allows business customers to choose whether to recycle or resell their old or outdated computer equipment.

Responsibilities of the Citizen: E-Waste prevention is perhaps more preferred to any other waste management option including recycling. Reuse, in addition to being an environmentally preferable alternative, also benefits society. By donating used electronics, schools, non-profit organizations, and lower-income families can afford to use equipment that they otherwise could not afford. While buying electronic products option for those that:

- ❖ Are made with fewer toxic constituents
- ❖ Use recycled content
- ❖ Are energy efficient
- ❖ Are designed for easy upgrading or disassembly
- ❖ Utilize minimal packaging
- ❖ Offer leasing or take back options



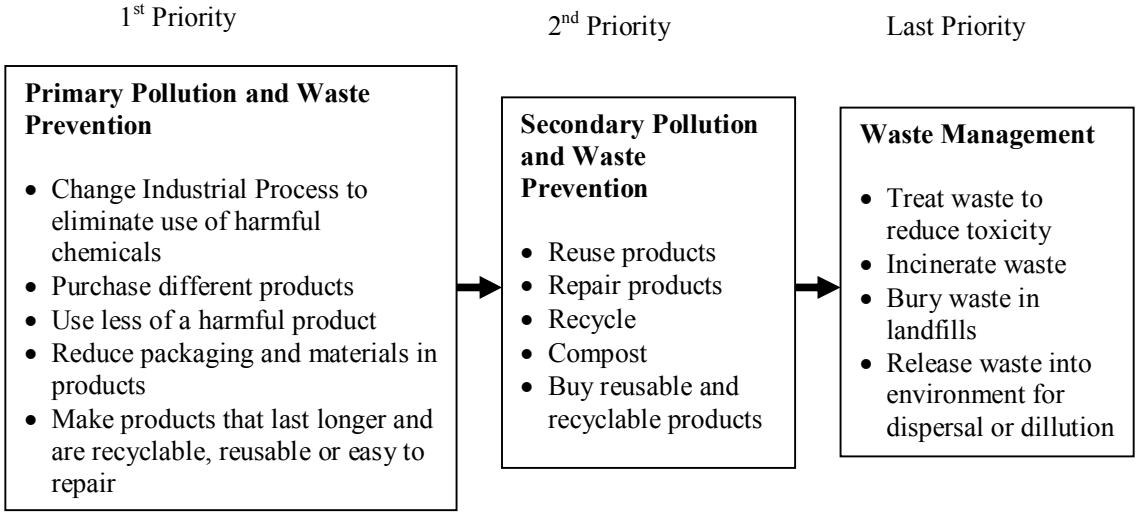


Fig.3: Waste management – priorities

Table -1: Effects of e-Waste constituent on health

Constituent	Desirable limit in drinking water	Source of e-wastes	Health effects
Lead (PB)	0.05 mg/l	Solder in printed circuit boards, glass panels and gaskets in computer monitors	Damage to central and peripheral nervous systems, blood systems, reproductive system and kidney damage. Affects brain development of children and endocrine system.
Cadmium (CD)	0.01 mg/l	Chip resistors, semiconductors and cathode ray tubes	Toxic irreversible effects on human health. Accumulates in kidney and liver. Causes neural damage. Teratogenic.
Mercury (Hg)	0.001 mg/l	Thermostats, sensors, relays, switches, medical equipment, lamps, batteries, and switches, printed circuit boards	Chronic damage to the brain, foetus and kidney. Respiratory and skin disorders due to bioaccumulation in fishes.
Hexavalent chromium (Cr) VI	0.05 mg/l	Corrosion protection of untreated and galvanized steel plates, decorator or hardner for steel housings	Asthmatic bronchitis. DNA damage.
Plastics including PVC		Cabling and computer housing	Burning produces dioxin. It causes Reproductive and developmental problems; Immune system damage; Interfere with regulatory hormones
Brominated flame retardants (BFR)		Plastic housing of electronic equipments and circuit boards.	Disrupts endocrine system functions
Barium (Ba)		Front panel of CRTs	Short term exposure causes: Muscle weakness; Damage to heart, liver and spleen.
Beryllium (Be)		Motherboard and finger clips	lung cancer Inhalation of fumes and dust. Causes chronic beryllium disease or beryllicosis. Skin diseases such as warts.
Aluminum	0.03 mg/l	All most all e-appliances	Dementia
Zinc	5 mg/l	plating for steel parts	Astringent taste and an opalescence in water

CONCLUSIONS

- ✓ e- Waste management is an integral part of health-care, and creating harm through inadequate e-waste management reduces the overall benefits of environmental protection and health-care.
- ✓ Build up of a comprehensive system addressing responsibilities, resource allocation, handling and disposal. This is a long-term process, sustained by gradual improvements.
- ✓ Awareness raising and training about risks related to e-waste, and safe and sound management practices.
- ✓ Safe and environmental-friendly management options are to be selected, to protect people from hazards when collecting, handling, storing, treating or disposing.

- ✓ Educating people about how to recycle, reuse, and dispose electronics at all levels will teach them and their communities how to behave more responsibly towards the environment. Indeed, electronic waste is a global problem requiring a global solution.
- ✓ Government commitment and support is needed to reach an overall and long-term improvement of the situation, although immediate action can be taken locally. In this context, it is essential to draft an action plan for the purpose of e-waste management in the country.

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