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Solid Waste Management (SWM) at a University Campus (Part 1/10): Comprehensive-Review on Legal Framework and Background to Waste Management, at a Global Context

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Abstract
This-work, being the-first, in-a-series of 10, was intended to-provide a-sufficient-introductory to SWM; *yet*, it can also-be-treated-as an-independent and a-complete-piece. This-article starts-with a-concentrated-digest (synthesized from over 400 published-reference-documents), providing a-starting point, for readers, interested in-advanced-investigation on the-topic. As-such, the-following-issues were presented and analyzed: SWM history; Global and regional-generation-rates; WM-'value-chain'; SWM-technologies; Impacts of uncontrolled-SW; International-Conventions, Protocols, Agreements, and commitments, addressing SWM, and their-analysis; as-well-as Global-SWM-practices (including municipal-waste management) and current-challenges, incorporating POPs. It was concluded, that waste is completely-unavoidable in-any, and every-human-activity; however, the-way the-waste is handled, stored, collected, and disposed-off, will-determine the-quality of our-surrounding-environment, to-be-either; clean, pleasant, healthy, and sustainable, or filthy, disgusting, harmful, and wasteful. The-way each-individual, company/organization, government, and society, at-large, deal with their-waste, will-eventually-determine our-own-future, as-humans. The-study also justified, that the-waste should-be-treated as a-resource, as it still-contains many-valuable-materials. The-study also-offered a-new-analogy; the-*sustainable* SWM-system should-be analogous to-a-digestive-system, extracting *all*-the-recyclables from the-waste, and *only* then discarding, the-small-remainder/waste. The-author, also-believes that Recycling (with a-capital R) is the-future of human-civilization; however, it *must* be done in the-environmentally sound-sustainable-manner, to-protect health of workers, and also to-extract the-optimum-amount of valuable-materials, from the-waste. This-study also-exposed, that despite the-existence of International, regional, and multilateral-agreements, illegal-trafficking of hazardous, toxic, radioactive, and e-waste, is still widely-practiced. Such-practices can-be regarded-as *Environmental-racism,* conducted by, or with the-help of, an-international-'*eco-mafia*'. Environmental-racism was analyzed against human-rights; in-the-context of both; the-Universal-Declaration of Human-Rights and the-generation-approach. The-author also-justified, that Environmental-racism is real, alive, and widespread-global-trend, affecting many, if *not* all-countries. Environmental-racism is a-sin, against humanity; logically, as any-sin, it should-be exposed, condemned, and fought against, with every-fibre, of impartiality, left in-us. The-study also-exposed an-increasing-interest of majority of African-countries in inherently-dangerous nuclear-energy (with its-by-product--radioactive-waste); the-recommendation was offered, to-shift their-interest to clean/green/renewable-energy-sector, particularly solar-energy. There is also a-common-prejudiced stereotyped-misconception, that, in-the-developed-countries almost-everything (including WM) is: superior, brainy, flawless, highly-organized, and tidy; in-contrast, in-developing countries, and particularly in-the-'dark'-continent of Africa, almost-everything (including WM) is substandard, mediocre, unsound, ad-hoc, and filthy. The-selected-examples, provided in-this-paper, will, possibly, demonstrate, that the-current-situation, at-least, with-regard-to WM, is *not* so 'black and white'. This-paper has also-offered several-recommendations for further-research. Lastly, this-article does *not* claim to-be *fully* comprehensive, as it-is physically-impossible 'to-fill an-ocean into a-small-cup', and even the-most-comprehensive-review, have to-stop, at a-certain-point. Nevertheless, the-cohesive-theoretical-background, alongside-with author's analytical-scholarly-input, hopefully provides a-credible-contribution to-the-body of knowledge, on-the-subject-matter, as-well-as a 'food-for-thought'. With anticipation, this-work will *not* only attract, but also hold, *considerable*-attention, from SWM stakeholders, and other-interested-parties, both; locally and internationally.
Keywords: Environmental racism, Convention, human rights, 'eco' mafia, POPs, e-waste, toxic, hazardous, radioactive, nuclear plants, solar energy, Africa.

1. Introduction.

1.1. Solid-Waste (SW): definitions, classifications, and generation-rates.

1.1.1. Solid-Waste (SW): definitions, and classifications.

The-World-Bank (2005) defines waste as 'unwanted, thrown-away, or discarded-as-useless, materials', which consist of organic-matter (that is easily-degradable) or inorganic-matter (*non*-biodegradable, for-example: metals, plastics, bottles, and broken-glasses) (Zhang *et al.,* 2010). The-Basel-Convention defines 'wastes' as

'substances or objects, which are disposed-off, or are intended-to-be-disposed-off, or are required to-be-disposed-off, by the-provisions of national law'. Simply-put 'wastes' are just 'stuff people throw away.

SW-characteristics differ, depending on-source and nature; and exist in two-forms, namely: refuse and trash (EPA-US, 2009). *Refuse*; includes garbage (highly de-compostable food-waste), rubbish (dry-material, such-as: metal, cans, glass, slow-decomposing-materials, combustible-materials, textile, and woods). *Trash*, on the-other-hand, comprises of bulky-waste-materials, which require special-handling, for-example: electronics, furniture, and household-items and equipments (World-Bank, 2005).

Besides, World-Bank (2012; 2005) classified, SW into eight-classes, as-follows: Industrial-waste; Commercial-Wastes; Residential-Wastes; Institutional-Wastes; Municipal-waste and services; Construction and demolition-debris and yard-wastes; Processed-waste; and Agricultural-waste. Moreover, there-are 5 main-types of waste; the-following-account shows the-types and their-sources: (1) *Organic* (Food-scraps, yard-waste (leaves, grass, brush), wood, process-residues); (2) *Paper* (Paper-scraps, cardboard, newspapers, magazines, bags, boxes, wrapping paper, telephone-books, shredded-paper, paper-beverage-cups. Strictly-speaking paper is organic, *but* unless it-is contaminated by food-residue, paper is *not* classified as organic); (3) *Plastic* (Bottles, packaging, containers, bags, lids, cups); *Glass* (Bottles, broken-glassware, light-bulbs, colored-glass); (4) *Metal* (Cans, foil, tins, non-hazardous aerosol-cans, appliances (white-goods), railings, bicycles); and (5) *Other:* (a) other-residue (ash, inert-materials, dirt, and sweepings), and (b) other-consumer-products (Textiles, leather, rubber, multi-laminates, e-waste, bulky-wastes, household-appliances, electronics, and multi-material-packaging (e.g., tetrapaks and blister-packaging).

Furthermore, some-waste-materials are of particular-interest, due-to-their-characteristics, and generation-patterns, or due-to-challenges, in their-management, e.g., e-waste (the-fastest-growing waste-stream, globally); end-of-life vehicles (EoLV); health-care-waste; hazardous-waste; toxic-waste; radioactive-waste; plastic-waste; marine-litter; disaster-waste; and food-waste. In-addition, 'new' waste-streams are emerging; for-example, *nano-waste*. The-chemical-physical-properties of nano-materials may pose risks to-human-health and the-environment, which are *not* yet entirely-known, or understood.

It-is also-important to-provide some-clarifications (for the-benefit to-the-readers), on the-types of waste, which people very-often-confuse, and use interchangeably, such-as: toxic, hazardous, and radioactive-wastes; there are, however, some-distinct-differences.

Radioactive-waste is a-waste, which contains radioactive-material. Radioactive-waste typically comprises a-number of radio-nuclides, which decay, emitting *ionizing*-radiation, harmful to-humans and the-environment. The- radio-nuclides, contained in-radioactive-waste, may-be: man-made, such-as caesium-137, or found in-nature, such-as radium-226. The-radioactive-properties of this-waste are: (1) the-type of radio-nuclides, contained, and the-radiation, emitted (alpha, beta, gamma), the-activity (number of atomic-nuclei, which spontaneously-disintegrate, per unit-time, expressed in Becquerels); and (2) the-radioactive half-life (the-time it takes, for a-radioactive-sample, to-loose half of its-activity) (Rogner, 2010). The-radioactivity of *all*-radioactive-waste weakens with-time. All-radio-nuclides, contained in the-waste, have a-half-life (the-time it takes, for half of the-atoms, to-decay into another-nuclide, and eventually, all-radioactive-waste decays into *non*-radioactive elements (i.e., stable-nuclides). The-process of decay can-vary, dramatically, for-example: According to Radioactive-isotope-table, the-shortest half-life of 190×10^{-12} seconds, is for Boron-16, while the-longest is for Tellurium-128, which-half-life ($(2.2 \pm 0.3) \times 10^{24}$ years) is over 160 trillion-times greater, than the-age of the-universe. Radioactive-waste is generated not only by the-nuclear-power-industry (from Nuclear fuel-cycle (Front-end and Back-end), but also from 'Legacy' waste, Nuclear-weapons-decommissioning, and the-use of radioactive-elements by hospitals, universities, and non-nuclear-industries, and defense-related activities. In-addition, there are also naturally-occurring radioactive-materials (NORM), for-example: uranium and thorium-radio-isotopes, from coal-combustion, that can-be-concentrated, as a-result of the-processing, or consumption of coal, oil, and gas (UNSCEAR, 2008). Classifications of radioactive-waste vary, by country. In-general, radioactive waste-categories are as-follows: very-short-lived-waste (VSLW); very-low-level-waste (VLLW); low- and intermediate-level short-lived-waste (LILW-SL); low-level-long-lived waste (LLW-LL); intermediate-level long-lived-waste (ILW-LL); and high-level and long-lived-waste (HLW-LL). Radioactive-waste is said to-be 'short-lived', if it merely only contains radio-nuclides, with a-half-life of less than 31 years, while it-is said to-be 'long-lived', if it contains a-significant-quantity of radio-nuclides, with a half-life of over 31 years (Ojovan & Lee, 2014). In-addition, there is also a-Trans-uranic-waste (TRUW), which is a-waste, contaminated with alpha-emitting trans-uranic-radio-nuclides, with half-lives greater-than 20 years, and concentrations greater-than 100 nCi/g (3.7 MBq/kg), excluding high-level-waste. Elements, that have an-atomic- number greater-than uranium, are called trans-uranic ('beyond uranium'). Exposure to radioactive-waste may cause serious-harm, or death; in-humans; a-dose of 1Sievert carries a 5.5 % risk of developing-cancer, and deletions, in-chromosomes. For-more-details see IRSN (2013).

Toxic-waste is any-material, in-liquid, solid, or gas-form; a-material is considered toxic, when it causes death, or harm, by being inhaled, swallowed, or absorbed, through the-skin (Vaughn, 2013). Toxic-materials are

poisonous-by-products of industries, such-as: manufacturing, farming, construction, automotive, laboratories, and hospitals, which may-contain heavy-metals, radiation, dangerous-pathogens, or other-toxins. According to Goodman *et al.* (2010), such-wastes often contain carcinogens. Toxic-material can-be either; naturally occurring, in the-environment, or human-made. *Not* all hazardous-substances are considered toxic. The-UNEP has identified 11 key-substances, which pose a-risk to-human-health: Arsenic, Asbestos, Cadmium, Chromium, Clinical-wastes, Cyanide, Lead, Mercury, PCBs (polychlorinated- biphenyls), POPs (persistent-organic-pollutants), and Strong-acids and alkalis.

In-regulatory-terms, a-*hazardous-waste* is a-waste, that appears on one of the-four RCRA (EPA Resource Conservation and Recovery Act) hazardous-wastes-lists (the F-list, K-list, P-list, or U-list), *or* that exhibits one or more-hazardous-characteristics, such-as being: explosive, flammable, oxidizing, poisonous, infectious, corrosive, toxic, and *eco-toxic* (Basel Convention, 1992; Bamako Convention, 1998). *Eco-toxic*, which is a-relatively-new-term, defined as "substances or wastes, which, if released, present or may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/or toxic effects upon biotic-systems". In-particular, with hazardous-wastes-lists, (i) the *F-list* (non-specific-source wastes), for-example spent-solvent-wastes; (ii) The *K-list* (source-specific-wastes); The-13-industries, that can generate K-list-wastes, are: wood-preservation; inorganic-pigment-manufacturing; organic-chemicals manufacturing; inorganic-chemicals-manufacturing; pesticides-manufacturing; explosives-manufacturing; petroleum-refining; iron and steel-production; primary-aluminum-production; secondary-lead-processing; veterinary-pharmaceuticals-manufacturing; ink-formulation; and coking (processing of coal, to-produce coke, a-material, used in-iron and steel-production); (iii) *The P-list and the U-list* (discarded commercial chemical-products); and (iv) *M-listed* wastes (discarded mercury-containing-products). Normally, the-mixture-rule, for the-listed-wastes, is applied, stating that a-mixture, made-up of any-amount of a-*non*hazardous solid-waste and any-amount of a-listed-hazardous-waste, is considered a-listed-hazardous waste. There are, however, 8 exceptions to the-rule. RCRA uses the-term 'solid-waste' instead of the-common-term 'waste'; under RCRA, the-term 'solid waste' means any-waste, whether it is a-solid, semisolid, or liquid. Moreover, materials can-be hazardous-wastes, even if they are *not* specifically-listed, or do *not* exhibit any-characteristic of a-hazardous waste; for-example, 'used-oil'. For-more-details see White & Heckenberg (2011); DECCW-NSW (2008); and EPA (2005).

1.1.2. SW: generation-rates.

The-estimated-quantity of Municipal-Solid-Waste (MSW), generated-worldwide, is 1.7-1.9 billion-metric-tons (UNEP, 2010). Globally, the-World-Bank estimates that the-amount of SW, generated by urban-areas, is growing, even-faster, than the-rate of urbanization. By 2050, as many-people will-live, in-cities, as the-population of the *whole world,* in-2000. World-Bank (2012), in its-global-review of SWM, forecasted, that by 2025 there will-be around 4.3 billion-*urban*-residents, generating about 1.42 kg/capita/day (2.2 billion tons/year) of SW. From 2002 to 2025, the-urban-population is expected to-increase by 148%, while the-waste-generation is expected to-increase by 222%.

In-addition, according to UNDESA (2014), in-1970, there was *only 3* mega-cities, all in the-North; in-1990 - 10 (half in the-North); and in-2014 - 28 (20 in the-South). For-instance, Kinshasa, the-capital of the-Democratic-Republic of Congo, had a-population of less than 4 million, in-1990, which had-risen to 11 million, by 2014, and is forecast, to-reach 20 million, by 2030. UNEP & ISWA (2015) also-projected, that by 2030, there-will-be 41 mega-cities (with population more-than 10million people, in-each), 32 of which, in-developing-countries, and lower-income-cities, in-Africa and Asia, will-double their-SW-generation, within 15-20 years.

Global SW-generation, by-region is as-follows (World-Bank, 2012): (1) 44% is generated by OECD (Organization for Economic Co-operation and Development)-countries (with an-average of 2.2 kg/capita/day); (2) 21% by EAP (East-Asia & Pacific-Region)-countries (0.95 kg/capita/day); (3) 12% by LAC (Latin-America and the Caribbean)-countries (1.1 kg/capita/day); (4) 7% by ECA (Eastern and Central-Asia)-countries (1.1 kg/capita/day); (5) 6% by MENA (Middle-East and North-Africa)-countries (1.1 kg/capita/day); (6) 5 % by SAR (South-Asia-Region)-countries (0.45 kg/capita/day); and (7) 5% by SSA (Sub-Saharan-Africa) with 0.65 kg/capita/day. As countries, particularly, India and China, continue their-rapid-urbanization and development, global SW-quantities are projected to-increase-considerably. According-to Cohen *et al.* (2015), in-2004, China already surpassed the-U.S.A., as the-world's largest-waste-generator.

World-Bank (2012) also-reported the-Waste-Generation, by Country-Income-Level, per-Capita (kg/capita/day): (1) High-income-level-countries (contributing 46% to the-globally-generated-waste, with an-average of 2.1 kg/capita/day; (2) Upper-Middle-income-level-countries (19% with 1.2.); (3) Lower Middle-income-level-countries (29% with 0.79); and (4) Lower-income-level-countries (6% with 0.6). Countries are classified into four-income-levels, according to World-Bank estimates of 2005 GNI, per-capita, as: High: USD 10,726 or above; Upper-middle: USD 3,466-10,725; Lower-middle: USD 876-3,465; and Lower: USD 875 or less. According to Terazono *et al.* (2005), as national-GDP increases, per-capita waste-generation, also-increases, suggesting even-higher-waste-generation, in-the-future. SW-generation-projection to-2100, by world-region, can-be viewed in Hoornweg *et al.* (2015).

It-is worth to-mention, however, that even in Low-income-countries there are people with high-income and *vice-versa,* hence the-averages were used, purely for illustrative-purpose. For-example, waste-generation, in-sub-Saharan-Africa, per-capita, is generally-low, with an-average of 0.65 kg/capita/day, *but* spans a-wide-range, from 0.09 to 3.0 kg/capita/day. The-SSA-countries, with the-highest per-capita rates are the-islands (e.g., Seashells and Comoros), likely due to-the-waste, generated by the-massive tourism-industry.

1.2. Solid-Waste-Management (SWM): definitions; history; goals; relevant-past-studies; technologies for the-processing and recovery, of resources, from waste, and their-shares; and impacts of uncontrolled-SW.

1.2.1. SWM: definitions, and history.

In-JICA-projects, the-term '*solid waste management'* is used to-refer the-management of the-chain of processes, which starts with discharge/storage and extends-through: collection, intermediate, treatment, and final-disposal of *all*-waste-materials (including both; hazardous and non-hazardous). Besides, Nathanson (2015), pointed-out, that SWM, as a-practice, is specific to a-particular-location/limited-geographical-area. SWM includes *all*-activities, which armed to-minimize health, environmental, and aesthetic-impacts of solid-waste (Da Zhu *et al.,* 2008).

Archaeological-studies, from clay-samples, have revealed that wastes from-different-sources, in the-past, formed stratified-layers, with-time (Bello *et al.,* 2016), hence it-is-possible to-examine these layers, to-reveal the-sources. In-the-ancient-history (10,000 B.C. to 4,000 A.D.), the-major-constituents of waste were generally-biodegradable, such-as: wood, food-wastes, dirt/dust, broken-clay-cooking-jars, etc. There were *no* industries, yet, and human-population was-quite-small; therefore, little-wastes, or manageable amount of waste, were generated. For-example: the-edible-part of the-waste was-fed to-animals, while the-remaining was allowed to-decompose, in the-ground, and there were nothing like WM-*systems* (Bello *et al.,* 2016); the-waste was managed, at household-level.

Systems of SWM can trace, their-roots, all-the-way-back, to-ancient-periods of human-civilization; one of the-very-first-(recorded)-instances of WM occurred at-about 3,500 B.C., in-the-city of Ur (Northwest of the-Persian-Golf), the-sweepings, from house-floors and the-contents of rubbish-bins were discarded, into the-streets. Such a-great-amount accumulated, that the-street-levels, were gradually-raised, and from-time-to-time new-doors were-cut, to-maintain-access to-houses (Columbus, 2006). Moreover, in 500 B.C., the-people of Athens (capital of Greece) developed the-first municipal-dumpsite, in the-western world, and required waste-disposal to-be, at-least, 1.6 km from the-city-walls (Arner, 2001; Lindenlauf, 2000). According to Columbus (2006), by 200 B.C., the-cities in-China had 'sanitary-police', whose job was to-enforce waste-disposal-laws. Collection of solid-wastes, at the-Roman-Empire, was probably better-organized, than that of any-other-civilization, of the-time. In-history, the-Romans were among the-first-people, who started a-WM-system, wherein some-collection-teams were organized, to-collect waste, generated in the-households and streets, for disposal, at the-outskirts of the-city (Cleary, 2009). Yet, the-Romans were *not* able to-overcome, easily, the-problem of dealing with the-large-accumulation of waste. Furthermore, the-Maya, of Central-America, had a-fixed-monthly-ritual, in-which the-people of the-village would-gather-together and burn their-rubbish, in-large-dumps (Lewis, 2007).

In-the 1340s, there was a-plague-epidemics (rightfully-termed as 'Black-Death') spreading in-Europe and Northern-part of Africa, which claimed about 75 million-lives (Liyala, 2011); scientists and doctors are now convinced that there is a-direct-link, between plague, and poor-sanitation and waste-management. Early WM-techniques were developed, to-combat the-spread of disease, during another-plague-outbreaks, in-Europe, between the-14th and 16th Centuries (Nathanson, 2015).

It was *not* until the-18th Century, that municipal-collection of garbage, had begun, in-some of the-world's major-cities, *but* the-methods were-still fairly-basic (Metzger, 2009). During the-Industrial Revolution, in 18th Century, Europe and the-U.S.A., were experiencing rapid-economic and technological development, that created greater-amounts of waste. Waste started to-become a-concern and the 'Age of Sanitation' began. Municipal-SWM, as we-know-it today, has its-origins in the-cholera-epidemics, which struck the-newly industrializing-countries, of Europe and North-America, from the-1830s. A-causal-link was-made to-decaying-organic-wastes, and the-public-health-revolution, focused-primarily on improving sanitary-conditions and collecting SWs. Besides, communities began to-organize waste-collection and disposal, to-help maintain public-health.

In-18th Century-England, the-streets became choked, with-filth, due to-the-lack of waste-clearance-regulations. Calls for the-establishment of a-municipal-authority, with waste-removal powers, were emerged, as-early-as 1751, by Corbyn Morris, in-London, who proposed that:"...as the preservation of the health of the people is of great importance, it is proposed that the cleaning of this city, should be put under one uniform public management, and all the filth be...conveyed by the Thames-river to proper distance in the country" (Velis *et al.,* 2009).

In-the 19th Century, in the-United-States, cities, often, became-choked-with horse-manure, as horses were the-main-means of transportation. Moreover, in-many-cities, lacking trash-collection, pigs and dogs ran loose,

consuming the-trash, *but* excreting dung, which smelled offensively (Gandy, 1994), moreover, dead-animals, particularly horses, were-left-lying, in the-streets, facilitating-diseases (Tarr, 1971).

In the-latter-part of the-19th Century and into the-20th Century, technological-advances included the-use of garbage-cans, and creation of incinerators, and sanitary-landfills; the-latter replaced the- condemned-practice of open-dumping, still common-practice in-the-developed-world (Hoornweg & Giannelli, 2007). In-1874, the-very-first-incinerator was built, in-Nottingham; later-on incinerators were nick-named 'destructors' (Lewis, 2007). The-first *close-body*-garbage-collection-trucks, to-eliminate-odors, with a-dumping-lever-mechanism, were-introduced in the-1920s, and the-first-truck, to-incorporate a-hydraulic-compactor, was introduced in 1938, in-Britain (Lewis, 2007).

1.2.2. SWM: Goals, and relevant-previous-studies.

The-principle-objective of SWM is to-preserve natural-resources, protect the-environment, and safeguard the-health of the-population (Munala & Moirongo, 2011).

The *Global-Waste-Management Goals* are: (1) to-ensure, by 2020, access for all, to-adequate, safe, and affordable SW-collection-services; (2) to-stop uncontrolled-dumping and open-burning; (3) by 2030, to-achieve sustainable and environmentally-sound-management of *all*-wastes, particularly hazardous wastes; to an-average of 3% of total-international-aid-funding, in-the-period from 2015 to 2030; (4) ensuring, by 2030, a-substantial-reduction in-waste-generation, through prevention and the-3Rs (reduce, reuse, recycle), thereby creating green-jobs; and more-specifically; (5) cutting, by-a-half, per-capita global-food-waste, at the-retail and consumer-levels, and reducing food-losses, in the-supply-chain. The-last three-points, in the *Global Call to Action* address these-goals and, thus, apply to *all* countries, *not* just developing-ones (WM & R, 2015; Lerpiniere *et al.,* 2014).

In-the developed-countries, SWM belong-to prominent-areas for research (Troschinetz & Mihelcic, 2009; Shekdar, 2009; Ferrara & Missios, 2005; Dijkgraaf & Gradus, 2004; Idris *et al.,* 2004). Previous-studies have addressed the-evolution of waste-management-systems, from the-viewpoints of: societal-background (Louis, 2004), policy-design (Jenkins *et al.,* 2008), technological-development and system-innovations (Murray, 2000) the-experiences of a-single-country, or city (Che *et al.,* 2013; Hara & Yabar, 2012; Kollikkathara *et al.,* 2009; Shekdar , 2009; Herbert, 2007), and composition and arising (Greater-London-Authority, 2011; Timlett, 2010; Poll & Kahlon, 2004; OECD, 2002).

This-review, on-the-other-hand, have focused-on legal-foundations, to-SWM, alongside-with current-practices and challenges, experienced, globally.

1.2.3. SWM: chain of operations and their-global-status

The-WM-'value-chain', includes the: collection, treatment, reuse, disposal, and recycling of various-waste-streams (UN-HABITAT, 2014). The-following-narrative provides some-details on-each of the-above-processes.

Collection coverage: According to Coffey & Coad (2010) and Beigl *et al.* (2004), SWM-services may-be-delivered by the: (1) formal-sector (*via* either; public or private-sector-operators); or (2) community or 'informal' sector (through community-based-organizations (CBOs), non-governmental organizations (NGOs), or micro and small-enterprises (MSEs)). Services may-be on a-relatively small-scale (providing primary-collection to local-neighborhoods), or on a-larger-scale (providing either; secondary collection, or an-integrated-collection-service, across the-city). Pickup of waste, is carried-out, by a-range of vehicle-types, such-as: bicycles, tricycles, tractor and trailer, tipper-trucks, purpose-build compaction-vehicles, and, sometimes, particularly in-developing-countries, by pushcarts, or animal- powered-carts. Data, compiled, for the-GWMO, from 125 countries, gives the-average collection-coverage in: (1) low-income-countries as 36%; (2) lower-middle-income-countries 64%; (3) upper-middle income-countries 82%; while (4) higher-income-countries approaching 100% collection-coverage. On a-regional-basis, collection-coverage has the-following ranges: Africa (25-70%); Asia (50-90%); Latin-America and Caribbean (80-100%); Europe (80-100%); and North-America (100%). Recent- publication of UNEP and ISWA, on Global-Waste-Management-Outlook, estimated that: (1) at-least 2 billion-people, globally, still lack-access to SW-collection (UNEP, 2015).

Recycling-rates, in high-income-countries, have progressively-increased, over the-last 30 years, driven, largely-by legislative and economic-instruments. In lower-income-countries, the-informal-sector is often-achieving recycling-rates of 20 to 30%, for MSW.

Disposal: At-least 3 billion-people, worldwide, still lack-access to controlled-waste disposal-facilities (UNEP, 2015; Tan, 2012). In-many developing-countries, more than 50% of the-collected waste is often-disposed-off, through uncontrolled-land-filling, and about 15% is processed, through unsafe and informal-recycling (Chalmin & Gaillochet, 2009). Uncontrolled-disposal (through open-dumping and burning) was the-norm, everywhere, until the-1960s, and according to the-World-Bank is still the-norm, in-most developing-countries. This-practice gives rise to-substantial-public-health, and environmental-risks. These-risks are notably-increased, in-cases, in-which hazardous-waste is mixed-with *non*-hazardous ISWA (2013a).

The-100% controlled-disposal, is generally-achieved, in-high-income-countries, the-rates in-upper-middle-income-cities (with an-average of 95%); in lower-middle-income-cities (with an-average of 70%), and with an-average 35%, in the-lower-income-cities, including 0% in-rural-areas. The-date of World-Urbanization-

Prospects (2014) suggests that, significant-progress is being-made, by some-cities, in middle-income-countries, with controlled-disposal-rates often of 70-95%; such-achievements compare well-with the-early take-up of controlled-disposal, in-Europe, in the-1970s and 1980s. The-situation is much-worse in low-income-countries, with uncontrolled-disposal-prevalence of 100%, in rural-areas.

Collection for recycling: Most 'recycling-rates' for MSW refer to-the-waste, collected, for the-very-purpose of recycling (UNEP, 2011). Recycling-rates are highest in the-high-income-countries, some low- and lower-middle-income-countries *do* collect 20 to 40%, for recycling (Dahmus & Gutowski, 2007); the-data, include the-collection of materials for both; 'dry-recycling' (e.g. paper, plastics, metals, glass, and textiles), and organic-recycling.

Recycling depends on two-aspects of 'segregation': (1) the-degree of mixing, and on-the-concentration of the-target-material/element, which can-be-addressed, through design for recyclability; and (2) to-keep different 'wastes' separate, at the-point of generation, to-ensure that they remain clean and uncontaminated, by other-waste-streams, this can-be-achieved *via* segregation, at-source (into organic and dry-recyclable-fractions). Products with a-lower- degree of mixing, and higher-values of the-component-materials, are cost-effective to-recycle, while those with higher-degrees of mixing and lower-values, are *not* (Velis & Brunner, 2013). The-presence of hazardous-components is particularly important: for recycling, to-be economically-feasible, recycling-streams should, ideally, be-contaminant-free. For-example, household-hazardous-waste (e.g. spent-batteries), if *not* segregated, can contaminate the-organic-fractions, and result in-compost that is contaminated by toxic-heavy-metals (Bartl, 2014).

In-2010, 700-800 million-tons of "waste" were recycled as 'secondary-commodities' (Regional 3R Forum in-Asia, 2013), derived from different-waste-streams. Considering both; tonnage and value, recycling-markets are dominated by ferrous-scrap (steel). In-tonnage-terms this is followed by paper and board, whereas in-terms of value, *non*-ferrous-metals rank second, with aluminum and copper dominating this-market.

1.2.4. SWM: technologies for the-processing and recovery, of resources, from waste, and their-shares.

A-number of technologies is used, for the-processing and recovery, of resources, from waste (see Dube *et al.,* 2014; World-Energy-Council, 2013; UK, DEFRA, 2013; ISWA, 2013b; Christensen, 2011; Rapport *et al.,* 2008; Eawag/Sandec & Waste-Concern, 2006), such-as:

(1) *Composting* (basically aerobic-decomposition of organic-wastes, with output-compost. Compost serves as soil-conditioner, mitigates erosion, and is used in-land-reclamation, and as a-final-cover for sanitary-landfills. This-technology is widespread in-high-income-countries, and has a-high-potential, particularly, in-developing-countries, with a-high-organic-fraction, in-SW. However, it-is not *yet* widespread, due-to operating-costs, and the-need, for source-separation.

(2) *Anaerobic-digestion* (AD) (Biodegradation of (readily-degradable) organic-wastes, in the-absence of oxygen, with anaerobic-microorganisms. 'Wet' or 'dry' variations are practiced. It-is widespread, mainly, for *non*-MSW. End-products produced are: Biogas, and digestrate, which can-be composted for use as soil-conditioner. The-method have-been attracting an-increased-interest, in-high income-countries, and for small-scale-low-tech, in-low-income-ones (mainly, to-meet the-heating and cooking-needs).

(3) Energy from waste (EFW), offers several-methods, such-as:

(a) *Combustion, with heat and energy-recovery* (Direct-combustion of waste, in the-presence of excess-air (oxygen), to-recover the-energy-content, of the-waste, as heat-energy, which can-be used directly, for heating, or as a-means of generating power (e.g. *via* steam-turbine-generators), or both (combined heat and power). It produces electricity and/or heat (heat-only, electricity-only, or both (CHP)). Energy efficiency ranges from up to 30% (electricity-only) to up-to 95% (CHP). The-approach completely sterilizes, destroys organic-compounds, including hazardous-wastes, outputting a-sterile-ash, while secondary-products produced, are Fe and *non*-Fe-metals and aggregate-recycling. It-is widely applied, in-Europe, the-U.S.A., Japan, and in the-PRC. The-approach attracts an-increased-interest, in rapidly-developing-economies. MSW, however, often too-wet to-burn, without auxiliary-fuel, therefore, increasing operational-cost; recovering the-costs of a-MSW EfW-plant, in-low- to medium-income countries is difficult.

(b) *Gasification* (Partial-oxidation of the-wastes, in the-presence of less-air (or other-oxidant), than required for complete-combustion); produces synthetic-gas (*syngas*). Japan and the-Republic of Korea, have had commercial-facilities, for gasification of MSW, for over 20 years; there is also an-interest, in-Europe, for small/medium-scale-plants; and a-potential, for wood-gasification-technology. India has one of the world's largest- programs, for small-gasifies.

(c) *Pyrolysis* (Thermal-degradation, in-the-complete absence of air, or other-oxidizing-agent), produces liquid-fuel. The-method is *not* widely-established, for MSW, even in developed-countries.

(d) *Mechanical-biological-treatment* (MBT) is a-combination of mechanical-processing, with biological-reactors, in the-same-plant. Bioreactors can-be bio-drying, or composting, or AD. The-method is very-common, in- Europe, with strong-interest, around-the-world. Configurations are available, at different-levels of cost and sophistication, suitable for developing-countries.

The-largest-contributing-technologies are various waste-to-energy technologies, particularly combustion, with-energy recovery (EfW). In-terms of distribution, by geographic-area, the-UK and the-U.S.A. show major-investments, accounting for 24% and 11%, of global MSW investment-activity, by-value, respectively, while the-most-active developing-countries are China (10%), and India (5%). Proportion of total-project-values, for MSW, by facility-type (based on data, which covers 2,723 facility-development-projects, active between January, 2013 and December, 2014, across 93 countries, in-all), is: (1) 44% - Combustion (with energy-recovery); (2) 15% - Waste-processing; (3) 11% - Gasification; (4) 9% - Integrated/mixed-facilities; (5) 8% - Recycling; (6) 5% - Landfill; (7) 4% - AD, biogas and bio-fuel; (8) 3% - MBT; and (9) 1%-others (http://acucomm.net/).

1.2.5 Impacts of uncontrolled-SW.

Throughout-history and throughout-the-world, cities have-struggled to-manage the-waste, produced by their-citizens (Columbus, 2006). Inadequate-WM has impacted, adversely, on public-health (Saffron *et al.,* 2003) and has caused environmental-degradation and resource-depletion (Emery *et al.,* 2003).

Improper-handling and disposal, of SW, has multi-dimensional-impact, such-as: pollution of air, soil, and water; contamination of surface and ground-water-supplies. Accumulated-waste and clogging of drains, creates stagnant-water for insect-breeding, resulting in the-spread of cholera, dengue-fever and other-infectious-diseases, and are a-major contributing-factor to-flooding (Wilson *et al.,* 2006). Accumulated-waste also a-cause of health and safety-problems (such-as diseases, spread by insects and rodents, attracted by garbage-heaps, and diseases associated with different-forms of pollution). Besides, some-dumpsites-sites are often alongside rivers or the-sea, and therefore may *directly* pollute them, as-well-as the-coastal-environment. Coastal-dumpsite-erosion is one-source of marine-litter. Other- potential-damage-costs include losses, resulting from decreases in-tourism, due to-polluted-beaches, and losses, incurred, through damage to-fisheries.

In-addition, rude-incineration, and burning of wastes, contributes considerably to urban-air-pollution, emitting particulate-matter, and persistent-organic-pollutants (POPs); greenhouse-gases (GHGs), generated from the-landfills and untreated-leachate, pose-threat to-humans, as-well-as to the-environment (Hoornweg *et al.*, 1999).

Besides, the-waste-sector was the-third-largest-contributor to-global-emissions of non-CO_2 greenhouse-gases, including methane, in-2005, accounting for 13% of total-emissions. The-two largest-sources of emissions are land-filling of solid-waste and wastewater, which together contributing 92-93% of emissions, throughout the-1990 to 2030-period. CH_4 from landfills accounted for an-average of 58% of waste-emissions, during this-period. According to WM &R (2015), direct waste-contribution, through methane (CH_4) emissions from anaerobic-decomposition of organic-wastes, at disposal-sites was estimated, by the-Intergovernmental-Panel on Climate-Change (IPCC) at around 3% of total GHG-emissions, in-2010. Increases in-waste-generation and population, drive the-quantity of these-global-waste-emissions continuously- upwards (EPA-US, 2009).

WM & R (2015) reported that around 1.3 billion-tons of edible-food-waste is globally-generated and dumped, every-year, representing one-third of all-food-produced, for human-consumption. Decomposing-organic-waste is a-rich-medium for the-growth of numerous micro-organisms, many of which can cause diseases, if *not* well-handled, and then passed-on to-humans (Adeyeba & Akinbo, 2002). Gastro-intestinal-infections, such-as gastro-enteritis, typhoid-fever, and helminthes, are commonly-linked to-poor-WM (Achudume & Olawale, 2007). Besides, uncontrolled-dumpsites, and in-particular the-mixing of hazardous and other-wastes, can cause diseases, in neighboring-settlements, as-well-as among waste- handling-workers. In-China, for-example, hazardous-WM-workers suffer of skin-lesions, malfunctioning of respiratory-system, cancer, or tuberculosis (UNEP, 2013a). More-details on the-impacts of uncontrolled: hazardous/toxic-waste, POPs, and e-waste, are provided in-sections 3.1.2; 3.1.3.1; and 3.1.3.2 (e), respectively.

2. International-Protocols, Conventions, agreements, and commitments to Environmentally-sound-management of wastes.

The-following-coverage presents *main* International-Conventions, Protocols, and Agreements, that directly, and indirectly, related-to SWM.

Convention on the Prevention of Dumping of Wastes and other Matter (London-Convention) **is** a 1972 International-treaty, which limits the-discharge of wastes, generated on-land, and disposed-off at-sea; with 81 parties to the-Convention. The-main-provisions of the-Convention can-be-summarized, as-follows: (a) a-definition of 'dumping'; 'black-list' and 'grey-list' of substances, and procedure, for their-disposal and amount of dumping; and (b) a-requirement for, at-least a-general prior-permit, for all-other-dumping. Besides, the-1996-Lindon-Protocol, which entered into force in-March 2006, is a-separate-agreement, to-modernize and update the-London-Convention. The-1996-Protocol, which incorporates both 'precautionary' and 'polluter-pays' principles, is intended to-protect the-marine-environment from *all*-sources of pollution. Contracting-parties shall-take effective-measures to-prevent, reduce, and, where practicable, eliminate marine-pollution, caused by dumping, or incineration, at-sea **(Extracted from the-London Convention, 1972).**

Montreal Protocol on Substances that Deplete the Ozone Layer **aimed** to-protect the-stratospheric ozone-layer. The-Protocol has 189 Parties, including the-U.S.A. It-came into-force, in-January, 1989 to-address chlorofluorocarbons (CFCs), halons, carbon-tetrachloride, methyl-chloroform, methyl-bromide, and hydro-CFCs. The-Protocol stipulates, that the-production and consumption, of these-compounds be-phased-out, and establishes schedules, to-achieve this-goal. The-Vienna-Convention for the-Protection of the-Ozone-Layer (1985), which outlines States' responsibilities, for protecting human-health and the-environment, against the-adverse-effects, of ozone-depletion, established the-framework, under which the-Montreal-Protocol was negotiated. The-Montreal-Protocol was further-amended in 1990, 1992, 1997, and 1999 **(Extracted from the-Montreal Protocol, 1989)**. Ninety-six-chemicals are currently controlled by the-Montreal-Protocol (UNEP, Ozone Secretariat). These-chemicals are commonly-found in-articles such-as: old-fridges and some-aerosol-sprays (Lundgren, 2012).

The-Basel-Convention on the Trans-boundary Movement of Hazardous Wastes and their Disposal was adopted in-Basel, Switzerland, on March 22nd, 1989 by the-Conference of Plenipotentiaries, in-Basel, Switzerland, in-response to a-public-outcry, following the-discovery, in-the-1980s, in-Africa and other-parts of the-developing- world of deposits of toxic-wastes, imported from-abroad. It entered into-force on May 5th, 1992. The-Convention includes hazardous-wastes, which are: explosive, flammable, poisonous, infectious, corrosive, toxic, or eco-toxic. The-Article 4, of the-Convention, requires each-Party to-minimize waste-generation, and to-ensure the-availability of disposal-facilities, within-its-own-territory. The-original Prior-Informed-Consent-procedure of the-Basel- Convention (Article 4.1) was strengthened by Parties' subsequent-decisions to-prohibit the-export of hazardous-wastes, from OECD to non-OECD-countries (Decisions II/12 and III/1). The-Convention imposes strict-conditions, on the-trans- boundary-movement of hazardous-wastes (Articles 4 and 6). Trade with non-parties is generally *not* permitted (Article 4.5). The-Convention also-provides for the-establishment of regional or sub-regional-centers, for training and technology-transfers, regarding the-management of hazardous-wastes and other-wastes, and the-minimization of their-generation, to-cater to-the-specific-needs of different-regions and sub-regions (Article 14). As of August 2015, 182 States and one-integration organization are Parties to the Basel-Convention (GWMO, 2015). More-recently, the-Convention formed the-Mobile-Phone-Partnership-Initiative, with industry, to-address the-environmentally sound management of end-of-life mobile-phones **(Extracted from The-Basel-Convention, 1992)**.

The *UN Framework Convention on Climate Change (UNFCCC)* is an-intergovernmental-treaty, developed to-address the-problem of climate-change. The-ultimate-objective of the-Convention is to-stabilize greenhouse-gas- concentrations, in-the-atmosphere, at a-level that would prevent dangerous human-interference with the-climate-system. The-UNFCCC entered into-force on 21st March, 1994; by December 2007, it-had-been-ratified by 192 countries. The-UNFCCC also-includes provision, under Article 10, for a-financial-mechanism to-support developing-countries and countries, with-economies in-transition, to a-market-economy, in implementing the-Convention (E**xtracted from** UNFCCC, 1994). With 195 Parties, the-Convention enjoys near-universal-membership.

Convention to Ban the Import into Forum Countries of Hazardous Waste and to Control the Trans-boundary Movement and Management of Hazardous Wastes within the Pacific (Waigami Convention) is a 1995 multilateral-regional-treaty, adopted in-Waigani, Papua-New-Guinea. The-Convention establishes hazardous-waste and radioactive-waste-import and export-ban-requirements, for the-South-Pacific-Region. The-Convention covers a-broad-range of hazardous-wastes, excluding those, derived from the-normal operations of a-vessel and some-radioactive-wastes (E**xtracted from the-Waigami-Convention, 1995).**

Convention on the-Ban on the-Import into Africa and the-Control of Trans-boundary-Movement and Management of Hazardous-Wastes within Africa (Bamako-Convention) is a-treaty of African-nations, prohibiting the-import of *any*-hazardous-waste (including radioactive). It-was adopted at the-Conference of Environmental-Ministers, in-Bamako, Mali, on 30th January, 1991, under the-auspices of the-Organization of Africa-Unity (OAU). Only-members of the-OAU are eligible to-become Parties to the-Bamako-Convention. The-convention came into- force in-1998. The-need, for the-Bamako-Convention, arose from the-failure of the-Basel-Convention to-prohibit trade of hazardous-waste, to-less-developed-countries (LDCs), and from the-realization, that many-developed-nations were-exporting toxic-wastes, to-Africa. The-Bamako Convention uses a-format and language, similar-to that of the-Basel-Convention, but is much-stronger, in prohibiting *all* imports of hazardous-waste. Additionally, it does *not* make exceptions, on certain-hazardous wastes, like those for radioactive-materials, made by the-Basel-Convention. Besides, the-Bamako Convention, unlike the-Basel-Convention, includes *any*-hazardous-substance, that has been banned, cancelled, refused, or withdrawn, from registration in the-manufacturing-country, for health, or environmental-reasons (E**xtracted from the-**Bamako-Convention, 1998). According to UNEP (2018), to-date, there are 29 Signatories, and 25 Parties to the-Convention. The-Parties (as per 15th March, 2016) are: Benin, Burkina-Faso, Burundi, Cameroon, Chad, Comoros, Congo, Côte d'Ivoire, Democratic- Republic of Congo, Egypt, Ethiopia, Gabon, Gambia, Libya, Mali, Mauritius, Mozambique, Niger, Senegal, Sudan, Tanzania, Togo, Tunisia, Uganda, and Zimbabwe.

Under the-*Stockholm-Convention* on Persistent-Organic-Pollutants (POPs), countries commit to-reduce and/or eliminate release of the 12 POPs of greatest-concern (the 'dirty dozen') into-the environment. The Treaty came into force on May 17th , 2004. The-Convention (Article 6) obliges Parties to-develop strategies for identifying Persistent-Organic-Pollutants (POPs wastes), and to-manage these, in an-environmentally-sound-manner. The POPs-content, of wastes, is generally to-be-destroyed, or irreversibly-transformed. Its-Article 3.2 restricts the-import and export, of POPs, to-cases where, for-example, the-purpose is *not* for environmentally-sound-disposal. It also-requires that, POPs *not* be transported across-international-boundaries, *without* taking into-account relevant- international-rules, standards, and guidelines (Article 6.1). The-Convention also-requires Parties to-take-measures to-reduce or eliminate releases of POPs, from intentional-production and use (Article 3), unintentional-production (Article 5) and stockpiles and wastes (Article 6). The-principles of Best-Available-Techniques (BAT) and Best-Environmental-Practices (BEP) are to-be-further-elaborated-for, and on-behalf of the-Conference of the-Parties (**Extracted from** the-Stockholm-Convention, 2004). Current-number of signatories is 152, and number of Parties is 182 (UNEP, Stockholm convention, 2018).

The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (PIC) promotes shared-information and responsibility, in the-international-trade of certain-hazardous-chemicals. Under PIC, importing-countries should-receive shipments, of banned or severely-restricted-substances, *only* after they have-had an-opportunity to-make an-informed-decision. A-total of 39 chemicals, currently, is subject to the-PIC-procedure: 24 pesticides, 11 industrial-chemicals, and 4 severely- hazardous-pesticide-formulations. The-Convention also-establishes a-process for listing new-chemicals. PIC has 112 parties, *not* including the U.S.A., and the-Convention entered into force on February 24, 2004. The-Convention (Articles 10 to 12) established a-Prior Informed-Consent-Procedure, based on-the-earlier-voluntary-guidelines (**Extracted from** the-**Rotterdam Convention, 2004**).

The Kyoto Protocol, was first-agreed in-December, 1997, in-Kyoto, Japan. The-Protocol obliges industrialized-countries, and countries, of the-former Soviet-bloc, to-cut their-emissions of greenhouse-gases, by an-average of about 5%, compared-with 1990-levels. The-Protocol entered-into-force, as a-legally binding-document, on 16th February, 2005; by December, 2007, the-Protocol had been-ratified by 177 countries (**Extracted from** the-Kyoto-Protocol, 2005).

The 2014 *Minamata Convention on Mercury* is a-new-international-treaty, with its-Article 11 on mercury-wastes. This-Article stipulates that mercury-wastes should-be treated in an-environmentally sound-manner, taking into-account the-guidelines, developed under-the-Basel Convention, and in-accordance-with requirements to-be- adopted by a-Conference of the-Parties to the-Minamata Convention. The-Minamata-Convention will-enter into- force, when 50 countries have-ratified it. As of August 2015, it has 12 Parties (GWMO, 2015).

The-Paris-Agreement (Accord de Paris)/Paris climate accord/ Paris climate agreement is an-agreement, within-the United-Nations Framework-Convention on Climate-Change (UNFCCC), dealing with greenhouse-gas-emissions mitigation, adaptation, and finance, starting in the-year 2020. It was adopted, by consensus, on 12th December, 2015 (Sutter & Berlinger, 2015). As of November 2017, 195 UNFCCC-members have-signed the-agreement, and 174 have-become party, to-it. The-Agreement aims to-respond to-the-global-climate-change-threat, by keeping a-global-temperature-rise this-Century, well-below 2 ^{o}C, above pre-industrial-levels, and to-pursue-efforts to-limit the- temperature-increase even-further to 1.5 ^{o}C (Paris-Agreement, 2016). According to Article 3, Paris-Agreement (2015), each-country determines, plans, and regularly-reports its-own-contribution it should-make in-order-to mitigate global-warming. There is *no* mechanism to-force (Globe & Mail, 2015), a-country to-set a-specific-target, by a-specific-date (Kinver, 2015), *but* each-target should-go beyond previously-set-targets. In-July 2017, France's environment-minister announced France's five-year-plan to-ban *all*-petrol and diesel-vehicles, by 2040, as-part of the-Paris-Agreement. France would *no* longer use coal to-produce-electricity, after 2022 and that up to €4 billion will-be-invested, in boosting-energy-efficiency (The-Independent, 2017).

Moreover, provision is made for the-obligatory-communication of hazard-information, under the-Basel-Convention (Article 4.2 f), the-Rotterdam-Convention (Article 5.1), and the-Stockholm Convention (Article 10). Furthermore, all three-Conventions address the-technical-assistance-needs, of developing-countries. The-Basel-Convention (Article 14) and the-Stockholm-Convention (Article 12) provide for regional-centers, for training and technology transfer, subject to-views of Conferences of Parties. The-Basel-Convention has a-Technical-Cooperation Trust-Fund, while Stockholm-Convention (Articles 13 and 14) has a 'financial-mechanism', operated by the-Global-Environment-Facility (GEF) for the-development of National-Implementation-Plans (BCRC, 2007).

3. Global-WM-practices and challenges.

3.1. Global- WM- practices.

Not so very-long-ago, as the-coastal-cities of the-U.S.A. grew-to metropolitan-regions, the-disposal of MSW was achieved by simply-loading-up large-barges, transporting them some-distance, from the-shore, and shoveling the-garbage, into the-water (Vesilind *et al,* 2002). The-same-practice was common among many-coastal-areas of

developed-world. Oceans, and other-water-bodies, were used as a-dumping-ground, for disposal of: chemical and industrial-wastes, radioactive-wastes, trash, weapons, sewage-sludge, and contaminated-dredged-material, among-others. Wastes were dumped, in-coastal and ocean-waters, based on the-primitive-assumption that marine-waters had an-unlimited-capacity to-mix and disperse-wastes.

Parmentier (1999) stated that: 'although *no* complete-records exist, of the-volumes, and types of materials, disposed, in-ocean-waters, several-reports do-indicate a-vast-magnitude of historic-ocean dumping'. Following decades of uncontrolled-dumping, some-areas of the-ocean became noticeably contaminated, with high-concentrations of harmful-pollutants, such-as: heavy-metals, inorganic nutrients, and chlorinated-petrochemicals. Parmentier (1999), also-stated, that the-uncontrolled ocean-dumping caused severe-depletion of oxygen-levels, in some-ocean-waters. Nowadays, the-vast-majority of material, disposed in the-ocean, is uncontaminated-sediment (dredged-material), human-remains, for burial, at-sea, vessels, man-made ice-piers, in-Antarctica, and fish-wastes. In-addition, under the-London-Convention, incineration, at-sea of industrial-waste and sewage-sludge, is prohibited. The-prohibited-incineration, at sea, however, does *not* include the-incineration of wastes or other-matter, on-board of a-vessel, platform, or other man-made-structure, at-sea, if such-wastes or other-material were generated, during their-*normal*-operations, at-sea.

The-following-account shows some WM-practices, which were-condemned, but *yet* to-be eliminated, completely.

3.1.1. Radioactive-wastes, oil-waste/spills, and plastic-waste

Every-summer, a-dumping-vessel *Gem*, and other-vessels, were-dumping, increasing-quantities of so-called *low-* and *intermediate*-level radioactive-wastes, originating from medical and-military-establishments, as well-as from nuclear-power-plants, from the-UK, Belgium, Switzerland and the-Netherlands. In-the-summer of 1982, the-largest-dumping-operation, ever-undertaken, officially-took-place; four-ships were-involved in-dumping 10,000 tones of wastes, representing nearly 130,000 Curies of radioactivity (the-Curie is a-unit, nearly-equal to the-rate of disintegration of 1g of Radium). This-dumping was protested by the-Greenpeace and its-supporters. Later-on, the-UK, France, Japan, the-U.S. A., Germany, Switzerland, Belgium, and the-Netherlands financed the-development of the-*sub-seabed disposal-option,* for high-level radioactive-wastes, equipped with drilling-gear; ships from these-countries would-shoot the-high-level-wastes, under the-seabed. The-three nuclear-reprocessing-facilities in the-OSPAR-region, La-Hague (France), Sellafield (UK), and Dounreay (UK), represent over 90 % of all-radioactive-waste-inputs, in the-region's marine-environment, and their-combined-releases, are by-far, the-largest in the-world. In-addition, report of the-15th Consultative-Meeting of Contracting-Parties to the-London-Convention, of 1992, reported that in-1991 and 1992, Greenpeace revealed, that the-USSR had-secretly been-dumping low-level radioactive-waste, as-well-as high-level-radioactive-waste, in the-Kara, and Barents-Seas, and the-Sea of Japan (Parmentier, 1999). A-recent-study, submitted by Greenpeace-International to OSPAR, showed that radiation-levels in the-vicinity of Sellafield, were comparable, to-those in the-Chernobyl-exclusion-zone (Sesini, 2011).

In-addition, to-radioactive-wastes, *oil-sludge* have also-been-dumped, regularly. For-example, in-May 1995, the-Greenpeace-International, have detected an-estimated-amount of 5,000 tons of oil, on the-Brent-Spar (Parmentier, 1999).

Moreover, dumping, at-sea, of *plastic-waste* is another-problem. According to Starovoytova *et al.* (2016), plastic-pollution is a pervasive-global-environmental-threat. More than forty-years of records show that there is plastic-debris in ocean-samples, from the poles to the equator (Thompson *et al.,* 2004). Results from these-samples have-demonstrated, that there was approximately three-times more-plastic in the water-column in the 1990s, compared with the 1960s, which is a significant-increase (Owen, 2004; Thompson *et al.,* 2004). Currently, there are five-main garbage-patches, in the-Pacific, Indian, and the-Atlantic-Oceans; the-largest is referred-to-as the-Great-Pacific-Garbage-Patch. *The garbage patch* is large-concentration, of marine-debris, in the-ocean. It-consists, mainly, of plastic-objects, with an-approximate-concentration of about 46,000 pieces, per-square-mile, according to UNEP (2015).

3.1.2. Hazardous and toxic-waste.

Historically, many-poor-developing-countries have large-external-debt, so they frequently-accept offers of multinational-companies, to-dispose hazardous-waste, in their-territory (Frohlich, 2003). According to Adeola (2001), multinational-corporations (MNCs) capitalize on the-following-factors, to-dump toxic/hazardous-waste, in the-weaker developing-countries: "weak or non-existing national environmental policy and standards in many developing countries, ineffective environmental laws and inadequate sanctions against polluters, a lack of adequate environmental law enforcement agents, bribery and corruption, and poverty or desperation to accept pollution for cash in many poor-countries".

For-example, in-late 80s', Benin was in a-difficult economic-situation, with a-huge foreign-debt. Desperate-government of Benin agreed to the-terms, of their-former colonial-master, France, to-receive several-million-tons of radioactive-waste, on its-territory, in-exchange for thirty-years of French financial-aid. Although the-media and civil-protests managed to-stop this-project, there is an-information, that a-part of this-waste,

nevertheless, ended in-Benin, illegally (Obradovi *et al.,* 2014).

In-1988, Guinea-Bissau was also-offered a USD 600 million-contract (4 times its-GDP), to dispose-off 15 million-tons of toxic-wastes, over five-years. The-contract was *never*-enforced, due-to public concern, within the-country. Many-other such-arrangements (legal-with the-consent of the-government, in-question; and illegal) were-reported in the-1980's, in-other African-countries, such-as: Namibia, Guinea-Conakry, and Sierra-Leone (Vir, 1989).

Besides, on 19th September, 1987, a-Danish-Ship (the-MV-Danix) shipped 3500 tons of toxic-waste, contained in 8000 drums, to-Nigeria. These-wastes, consisting of polychlorinated-biphenyls (PCBs), methyl-melamine, dimethyl-formamide, ethylacetate, formaldehydes, and others, were dumped at Koko, a-small coastal-town, in-Bendel-State (now Delta-State). They were stored in the-backyard of the-illiterate-Chief, of the-area, Sunday Nana, who was paid a-monthly-storage-fee of N500 (the-equivalent of USD 5). Due-to-ignorance, of the-dangers, associated with these-substances, the-Chief soon converted some of the-drums into water-storage-containers, for domestic-consumption. Afterwards, the-matter become public, and led to a-diplomatic face-off, between Nigeria and Italy, which was resolved by sending the-wastes-back to-Italy and subsequent-rehabilitation of the-affected-land, and relocation of the-people, at the-vicinity (Akingbade, 1991). Many-drums were damaged and leaking; workers, packing drums into-containers, for re-transportation to-Italy, suffered severe-chemical-burns, some were hospitalized, while one-man was-paralyzed. After the-waste was-removed, land within a-500 meter-radius, of the-dump site, was declared unsafe, with concerns about surface and groundwater-contamination (Vir, 1989).

In-addition, on February 4, 1988, the *Bark*, a-merchant-vessel, owned by Bulkhanding of Norway, sailed-off the-shores of the-U.S. A., with a-load of 15,000 tons of toxic-incinerator-ash, from Philadelphia. The-ship initially-headed for Haiti, one of the-world's poorest-states, *but* due to a-massive-protest by Haitians, at Port-au-Prince, Bulkhanding's managers changed the ship's manifest to Guinea, small-West-African-country. According to the Guinean-government-statement, the-importation of the-toxic-waste was arranged by a-local Guinean-firm, SIAG, an-investment-firm, jointly-owned by Guinean-businessmen and Norwegian-expatriates. The-toxic/hazardous-waste was imported as 'raw material for bricks' (Gwam, 2011). But, soon after the-waste was buried, the-devastating-effect became evident – plants and trees died, instantly, and *Kasa* (the-place of dumping) ceased to-be the-tourist-attraction, which it had been. Due to-massive-protests, the-cargo was returned to Philadelphia, on July 22, 1988 (Gwam, 2011).

Moreover, the-most-recent and the-most-devastating-incident of hazardous-waste-dumping, to-Africa, happened on 19th August 2006, after refusing of a €1,000, per-cubic-meter disposal-charge, in-Amsterdam, and being-turned-away by several-countries, the *Probo Koala ship* offloaded more-than 500 tons of toxic-waste at the-Port of Abidjan, Côte d'Ivoire (Ivory-Coast). This-waste was then spread, across the-city and surrounding-areas, dumped in-waste-grounds, public-dumps, and along roads, in poor-populated-areas. This-waste gave-off toxic-gas, and resulted in-burns to lungs and skin, as-well-as severe-headaches and vomiting. 17 people were confirmed to-have-died and at-least 40,000 were injured. The-ship's-administration has claimed that the-waste was simply a-dirty-water ('slops'), used for cleaning the ship's gasoline-tanks, *but* a-Dutch-government-report, as-well-as an-Ivorian-investigation, dispute this, finding that it was, indeed, a-toxic-waste, containing two 'British tons' of hydrogen-sulfide (Banks *et al.,* 2008).

Although the-issue of hazardous-waste first-received international-attention, because of these-incidents, the-problem is by *no* means confined to-Africa. Numerous-incidents of dumping, in-developing-countries have-been reported, throughout-the-world (Vir, 1989). For-example, according to the-Thompson-Environmental-Services, Australia, in-1993, exported USD121 million-worth of hazardous-wastes (79% went-to OECD-countries, and the-rest, to non-OECD-countries: India, China, Indonesia, Korea, Malaysia and the Philippines). Exports to-China totaled over USD 5 million (mercury USD 5 million, and lead-acid-batteries USD 175,000). Besides, Australia's exports of amber-listed-wastes (*only* for final-disposal) in 1994/95 amounted to USD 48.3 million (USD 18.56 million were traded with non-OECD-countries, and exports, worth USD 29.74 million, were traded with OECD-countries). In-1992, Australia also-exported large-quantities of lead-acid-battery-waste, for-recycling, to Asian-countries, such-as: the-Philippines, Taiwan, Thailand, Hong-Kong, Indonesia, Japan, New-Zealand, and Papua-New-Guinea. Greenpeace reports, that the-majority of these-exports were *not* dealt-with in an-environmentally-sound-manner, resulting in damage to-human-health, and the-environment, in: Indonesia, Thailand, and the- Philippines (Greenpeace, 1994). During 1993-1996, Singapore, Saudi-Arabia, and Australia, have-emerged as the-top-three major-exporters of drained or un-drained-scrap-batteries, to the-Philippines. Although, legitimate- hazardous-waste recycling-operations, being promoted by the-Philippine-government, they do pollute the-environment, with toxic-emissions, creating residual hazardous-waste, more-toxic than the-original-waste (Greenpeace, 1997). More-recently, in-November, 2000, more-than 160 containers of hazardous/toxic-wastes were illegally-imported in-India's Bombay-Port, by traders, based in the-Arabian-Gulf; the-Greenpeace advocated returning the-wastes to the-exporters, at the-expense of the-exporters (Greenpeace, 2000).

3.1.3. Relatively-recent waste-streams: POPs, and E-waste.

3.1.3.1. POPs

The-persistent-organic-pollutants (POPs), is a-group of semi-volatile-toxic-chemicals. As their-name suggests, they exhibit remarkable-persistence; it may take them centuries, to-be-degraded; they persist for long-periods of time, in the-environment, and can-accumulate, and pass from-one-species to-the-next, through the-food-chain (EPA-US, 2009). POPs are, mainly, of an-anthropogenic-origin, such-as: industrial processes, waste (e.g., medical), traffic-fumes, and agriculture; and a-few of natural-origin, e.g., from volcanic-eruptions. In-addition, their-long-range-transport leads to global-pollution, as they have the-ability to-travel, over great-distances, from the-source of release, through air, water, and migratory-animals, often-contaminating areas, thousands of kilometers, away from any-known-source. POPs are also lipophilic (have a-tendency to-remain, in fat-rich-body-tissues); and tend-to bio-accumulate, this means that, even small-releases of POPs can-have significant-impacts.

The-Stockholm-Convention is a-global-treaty, ratified by the-international-community, and led by the-United-Nations-Environment-Program (UNEP), that calls for the-elimination and/or phasing-out of 12 POPs, called the '*dirty dozen',* including:

(1) *8 pesticides* (Aldrin, Dieldrin, Chlordane, DDT (dichlorodiphenyl-trichloroethane), Endrin, Heptachlor, Mirex, and Toxaphene), were introduced in 1940-1950s, banned later-on, *but* still in-use in-some-countries. According to-UNEP (2009b), many-developing-countries, and countries in-transition, face challenges with hot and humid-climatic-conditions, that promote the-growth of various and numerous-pests, necessitating pesticide-use. Besides, DDT is used to-control-mosquitoes, which carry malaria (EPA-US, 2009). To-give just one-example, of possible long-term DDT-effects, that were identified as-follows: Association-with low-birth-weight and length-of gestation (Farhang, 2005); Reduced seminal-parameters (De Jager, 2006); Impaired-semen-quality (Aneck-Hahn, 2007); Male genital-anomalies (Bhatia, 2005); Breast-cancer, in young-women (Cohn, 2007); *In utero* exposure associated-with neuro-development (Eskenazi, 2006); Association-with infant-neuro-development (Torres Sánchez, 2007); and Beneficial-effects of breastfeeding, on-cognition, regardless of DDT-concentrations, at-birth (Ribas-Fitó, 2007);

(2) Two-industrial-chemicals: (a) *PCBs* (polychlorinated-biphenyls; e.g., trade-names for different-mixtures (partial-list) are: Aroclor, Pyranol, Pyroclor, Phenochlor, Pyralene, Clophen, Elaol, Kanechlor, Santotherm, Fenchlor, Apirolio, and Sovol); and (b) *HCB* (hexachlorocyclohexane) was used as a-fungicide, in-the-past. PCBs cause acute, high-level toxicity, which is well-characterized. In-particular, PCBs have-caused well-documented-episodes, of mass-poisoning, called 'Yusho' & 'Yu-Cheng' phenomenon. The-name was given, based on two-main mass-poisoning-episodes, that have-occurred; one in-Japan ('Yusho', in the-1960s) and one in-China, Province of Taiwan ('Yu-Cheng' in the-1970s). The-phenomenon manifests in adverse, persistent-effects, in-newborns, such-as: low-birth-weight; reduced-growth; hyper-pigmentation; gingival-hyperplasia; eye-adenoma; dentition, at-birth; and skull-calcifications (Chen *et al.,* 1994; Kuratsune *et al.,* 1986); and

(3) *Two-unintended-industrial by-products* (Dibenzodioxins, and Dibenzofurans). These are the-by-products of production of other-chemicals. Detected in-incineration of: coal, peat, wood, hospital-waste, hazardous-waste, municipal-waste, car-emissions. Out of 210 known-dioxins and furans, 17 are in toxic-mixtures.

POPs are among-the-most dangerous-substances (GEF, 2009); some of the-severe-health-impacts from POPs include: cancer, damage to the-central and peripheral-nervous-systems, reproductive-disorders, and disruption of the-immune-system. For-example, long-term, low-level-exposure, of humans, to-dioxins and furans, may lead to-the-impairment of the-immune-system, the-impairment of the development of the-nervous-system, the-endocrine-system, and the-reproductive-functions (EPA-US, 2009). Short-term, high-level-exposure may result in-skin-lesions and altered-liver-function. Some-POPS are also-an-endocrine-disruptors (see Hites, 2004; Solomon & Weiss, 2002). Besides, exposure of animals to-dioxins, has resulted in-several-types of cancer (WHO, 2011).

According to the-modeling-results MCS-E & NULU (2014), elevated-levels of PCDD/F air-concentrations (> 10 fg TEQ/m^3) are characteristic of Europe, Southern and Eastern-Asia, and Africa, while lower-levels of POPs-pollution are indicated for North and South-America, and Australia. On-the-other-hand, POPs-highest-levels found in-marine-mammals. Humans and animals are exposed, mainly, *via* ingestion of contaminated-aquatic-foodstuffs. Main-dietary-concern, for humans, regarding POPs, are: large-fish, shellfish, marine-mammals, meat, milk, and other-dairy-products. The-median-levels reported, in-fish, in-various-countries, are of the-order of 100µg/kg (on a-fat-basis).

Linderholm *et al.* (2010), points-out that the-information on-POPs, in-Africa, is scarce, and does *not* allow evaluation of population-exposures-levels and changes, over-time. However, compilations of available air, soil, and human-data, are found in the-UNEP regional-reports (UNEP, 2009a), and there is also some-additional-data on various chlorinated-pesticides, in human-milk, and serum, from both; urban and rural-populations, such-as in: Kenya (Kinyamu *et al.,* 1998), Uganda (Ejobi *et al.,* 1996), Zimbabwe (Chikuni *et al.,* 1997b; Chikuni *et al.,* 1997a), South Africa (Dalvie *et al.,* 2004; Okonkwo *et al.,* 2008); Tunisia (Ennaceur *et al.,* 2008), and Guinea-

Bissau (Linderholm *et al.,* 2010).

POPs particularly-affect developing-countries, where systems and technology for monitoring, tracking, and disposing of them, can-be weak, or *non*existent. Across-Africa, for-example, at-least 50,000 tons of obsolete-pesticides are contaminating soil, water, air, and food-sources. The-Africa Stockpiles Program (ASP) was launched in-September, 2005 with the-goal to-clear all-obsolete-pesticide stocks, from Africa, and to-establish measures to-help-prevent their-recurrence. In-Tunisia, one of the-first ASP-projects, 1,200 tons of obsolete-stocks was identified at large-number of containment-sites (GEF, 2009). Sub-Saharan-countries also-face particular-challenges, because waste-treatment-technologies, that meet the-Stockholm-Convention's guidelines on Best-Available-Technologies (BAT), and Best Environmental Practices (BEP), and fit local-circumstances, are simply *not* available, at-market-prices, that facilities or their-Governments, can afford (WHO, UNDP, GEF, & CHWH, 2016). Lammel *et al.* (2009), also pointed-out, that monitoring of POPs in-air in-Africa was, so-far, limited to-one-town in the-Republic of South-Africa, in-2004.

Furthermore, most-recently, the-parties to-the-Stockholm-Convention, in-May, 2009, took the-historic-decisions to-add 10 new-chemicals, to-the-list of controlled-substances, under the-Convention: (1) alpha- and beta-hexachlorocyclohexane (by-products); (2) lindane and chlordecone (pesticides); and (3) tetra- and hexabromodiphenyl-ether, hexabromobiphenyl, pentachlorobenzene, perfluorooctane-sulfonic acid, and perfluorooctane-sulfonyl-fluoride (industrial-chemicals) (GEF, 2009). For the-most updated-list of substances, covered by the- Stockholm-Convention, please visit www.pops.int.

3.1.3.2 E-waste

(a) Definitions and classification

The-Organization for Economic Co-operation and Development (OECD) defines *e-waste* as 'any appliance using an electric power supply that has reached its end-of-life' (UNEP-DTIE, 2007). The-most widely-accepted-definition of e-waste is as-per European-Commission-Directive 2002/96/EC, is: "electrical or electronic equipment, which is waste … including all components, subassemblies and consumables, which are part of the product at the time of discarding" (European-Commission, *n.d.(a)).* Besides, e-waste refers to all-types of electrical or electronic-equipment (EEE) and its-parts, that have-been-discarded, *without* intention for reuse, by the-owner (StEP, 2014c). E-waste usually-encompass either; a-battery, or a-power-cord, or both (Brune *et al.,* 2013).

E-waste generated from discarded EEE, is commonly-divided-into 3 main-categories: (1) large-household-appliances (e.g., refrigerators and washing-machines), (2) information-technology (IT) and telecom (personal-computers (desktops and laptops), monitors, printers, scanners); and (3) consumer equipment (TVs, DVD-players, stereos, VCRs, video-game-consoles, digital-cameras and camcorders, mobile-phones, mp3 players, and leisure and sporting-equipment). Equipment-components, including: batteries, circuit-boards, plastic-casings, cathode-ray-tubes, activated-glass, and lead-capacitors, also are considered-to-be e-waste (UNEP, 2007).

(b) Trends

E-waste is 'the-fastest-growing waste-stream, in-the-world' (UNEP, 2013b). The-e-waste global-problem has been-building-up, for decades; for-example: between 1994 and 2003, about 500 million-personal computers, reached their end-of-life, and hence, needed to-be-disposed-off.

Short-innovation-cycles of electronics, fuelled the-ever-growing-consumer-demand (desire for new/trendy/more-advanced and cheaper-products), a-high-product-obsolescence-rate (Basel-Action Network, 2011; UNEP-DTIE, 2007a); the-growth in internet-use; low-recycling-rates, relatively-short lifespan of electronics, due-to complexity and cost of repair/recycling, all contribute to-rapidly-rising quantities of e-waste. Starovoytova *et al.* (2016) pointed-out, that:

> Overall, both developed and developing-countries can be regarded as to be dominated by a "throw-away-society", where the-norm is to-produce short-lived-products, in-order-to-keep producing more and more. Natural-resources are relentlessly-exploited in-order-to-satisfy the society's demand for use-and-toss products, where reusing and recycling-practices is, apparently, *not* a priority.

In-the-same-accord, Zerberk (2003), identified such-practices, as the-'buy and discard'-mentality. Moreover, EPA-US (2007), stated that today, it-is often cheaper to-discard malfunctioning-consumer-electronics, and replace-them, with-newer and more-technically-advanced-products. The-EPA estimates the-following short-life-spans for some-electronic-products: Desktop-computer: 2-4 years; Laptop-computer: 2-3 years; Cell-phone: 1-3 years; and Flat-screen-television: 7-13 years. Currently, e-waste is the-fastest growing-source of waste, worldwide (Brune *et al.,* 2013; Lundgren, 2012; Widmer *et al.,* 2005), at estimated 4% annual-growth (Schluep *et al.,* 2009).

Figure 1 shows the-average-rate of e-waste-generation, per-person, per-year, in-different continents. Besides, it was projected, by UNU (2013), and quoted by StEP (2014a); and Breivik (2014), that global-e-waste will-increase by around 33% ; from 49.7 million, in-2014, to 65.4 million-tons, per-annum, by 2017. UNEP (2005) also estimated, that e-waste, in-emerging-economies, like South-Africa, China, and India, will-have-increased by 200-500%, over 2007-levels.

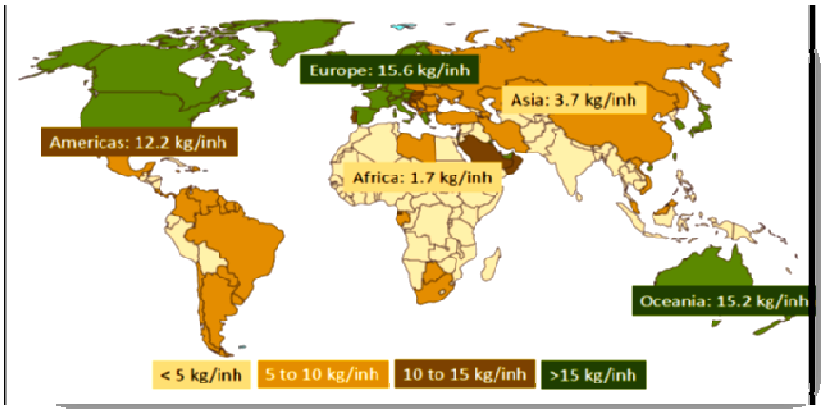

Figure 1: E-waste-annual-generation, per-capita (*inh.*), 2014 (UNU, 2017).

(c) Valuable-materials in e-waste

More-than 60-chemical-recyclable-elements can be-found in-various-complex-electronics (Grant *et al.,* 2013). Iron and steel constitutes about 50% of e-waste, followed by plastics (21%), *non*-ferrous-metals (13%), and other-constituents (UNEP, DTIE, 2007a). A-mobile-phone, for-example, can contain more than 40 elements, including base-metals, such-as copper, special-metals, such-as cobalt, and precious-metals, such-as gold, which are very-valuable, and hence, desirable, for recycling (StEP, 2014b).

According to Electronic-waste, the-composition of e-waste differs, from one-product to-another. Some-elements are found in large-quantities, while some are found in-small and trace-amounts. In-particular, substances found, in e-waste, including (1) *in-large*-quantities, are: Epoxy-resins, fibre-glass, PCBs, PVC, thermosetting-plastics, lead, tin, copper, silicon, beryllium, carbon, iron, and aluminum. For-example: a-mobile-phone contains around 19% copper and 8% iron (Greenpeace, 2009); (2) *in-small*-amounts, are: Cadmium, mercury and thallium; while (3) in *trace*-amounts, are: Americium, antimony, arsenic, barium, bismuth, boron, cobalt, europium, gallium, germanium, gold, indium, lithium, manganese, nickel, niobium, palladium, rhodium, ruthenium, selenium, silver, tantalum, terbium, thorium, titanium, vanadium, and yttrium.

Table 1 shows an-estimated e-waste-material-recovery, in-selected-electronic-products/appliances, compiled by PETEC (Panasonic-Eco-Technology-Centre, Japan).

Table 1: E-waste material-recovery (PETEC, 2001).

	Flat Panel TV	Liquid Chrystal	Cathode ray tube TV	Washing machine/ dryer	Air Conditio ner	Refriger ator
Copper	1%	1%	3%	4%	17%	4%
Plastic	10%	40%	23%	36%	11%	40%
Aluminium	19%	4%	2%	3%	7%	3%
Iron	21%	30%	10%	53%	55%	50%
Glass	29%	6%	57%	-	-	-
Others	20%	19%	5%	4%	10%	3%

Only an-estimated 15%, of global e-waste, however, is *fully* recycled (Modak, 2011), to-extract these-valuable-materials, the-rest is discarded.

(d) Practices and challenges

In-recent-years, the-media and environmental-groups, have regularly-exposed the-smuggling and dumping of e-waste (Lundgren, 2012); such-practices become a-global-phenomenon. High-labor-costs and stringent environmental-regulations, for hazardous/e-waste-disposal, in-developed-countries encourage the-exportation of e-waste, to-less-developed and less-regulated-countries (Perkins *et al.,* 2014). Lundgren (2012), for-example, cited EPA-US, revealing that it was 10 times-cheaper to-export e-waste, to-Asia, than it was to-process-it, in the-United-States. Besides, following a-three-year undercover-investigation, by Greenpeace-Movement, it was discovered, that e-waste, was *not* properly and responsibly-recycled, in- the-U.S.A. and Europe. Instead, e-waste

is being-disguised as second-hand-goods, and shipped-off to-developing-countries, where it-is sold, scrapped, or illegally-dumped (Greenpeace, 2009).

For-example on-lack of e-waste-regulations, Ghana has an-unregulated and unrestricted-import regime, for second-hand-EEE. In-2009, 70% of EEE-imports, into-Ghana, were-designated-as second-hand products, *but* considerable-amounts of these-imports, were near, or at end-of-life, and quickly designated as-e-waste, due-to-little, or *no* utility-value (Amoyaw-Osei *et al.,* 2011; Van der Herten, 2008; BAN, 2011). As a-result, the-EEE-products, identified/labeled for 're-use', *only* ends-up contributing to the-e-waste problem, in-the-developing-recipient-countries (The-Lancet, 2013). E-waste-flow, however, is a-complex issue; the-flow of e-waste includes more-than just-movement, from-developed to-the-developing-countries. For-example, in-2001, Africa exported most of its-e-waste to Korea and Spain (Lundgren, 2012). E-waste, imported into-China is often-re-exported to-other South-East-Asian-countries, including Cambodia and Vietnam (Ni & Zeng, 2009). According to Zoeteman *et al.* (2010), West-Africa might-become a-more common-destination, in the-future, together with Eastern-Europe.

Figure 1 showed that EU is the-largest e-waste-generator, per-person. Approximately 25% (2.1 million-tons) of the-estimated 8.7 million-tons of e-waste, produced in-the-European-Union (EU), each-year, is collected, and recycled, in-formal-processing-plants, where workers are protected by modern-industrial-standards. The-remaining 75%, however, is added to-the 'hidden-flow' of untraced and unreported e-waste (Perkins *et al.,* 2014), and according to the-European-Environment-Agency' estimates, up-to 1.3 million-tons, of discarded EEE, are exported, from the-EU, annually, mostly-to Africa and Asia (Lundgren, 2012), mainly, for reuse (as donations, second-hand-goods), small-fraction is also-sold, for recycling (Diaz-Barriga, 2013).

For-example, in-the-*Goodwill-company*, U.S.A., with over 3,000-donation-locations, nationwide, people are constantly donating, their-old-electronics, with good-intensions, to-help the-poor, abroad. According-to-PACE, a-charitable-donation is the "transfer of computing equipment or its components, which are not waste, for their intended direct reuse for purposes of charity without any monetary rewards or benefits, or for trade" (UNEP, 2013a; Pace, 2008). Simply-put: the-equipment should be in-good-working order, and it should *not* be for sale. In-most-recipient-countries, however, the-e-waste dealers, first and foremost, select the-functioning-equipment, and sell it, directly, or for refurbishment and further re-sell to-customers; the-rest/e-waste is also-sold to e-waste-scrap-dealers/recycles, mostly in-the-*informal*-sector. Analyzing such-common-scenarios, we can conclude, that there-is a-trade, of a-sort, although an-illegal-one, as money do change-hands, severally.

The-primary-driver of this-trade is that e-waste contains very-valuable-components, is easy to-source, and relatively-cheap to-ship, and the-risk of being-caught is generally-low (Interpol, 2010). Another-example of the-value-driver, of the e-waste-trade, is the-corruption-scandal, which broke-out in-Singapore, in-2005, with e-waste-recycling-firm Citiraya. Computer-chips, meant to-be-recycled were being-diverted, for sale, overseas, besides the-level of precious-metal, extracted from-waste, was falsified, with about USD161 million, in fake-sales-created, between 2003 and 2005 (Vijayan, 2008). According to Lundgren (2012), trans-boundary-movement of e-waste is primarily profit-driven; looking at the-ever increasing-volume of e-waste-movement, it can be assumed, that the-e-waste-export/ import/management and processing also a-profitable-trade/business, if *not* lucrative-one.

The-major-stakeholders, in the-life-cycle of e-waste, include: producers/manufacturers, retailers (businesses/government/others), consumers (individual households/businesses/government/others), traders, exporters and importers, scrap dealers, disassemblers/dismantlers, smelters and recyclers (UNEP, DTIE, 2007a). Some of the-stakeholders are initiators, and active-participants in the-e-waste-trade. The-following narrative will track the-practices of e-waste-disassemblers/dismantlers, smelters and recyclers.

According to-Greenpeace-International (2008), the-EU has-ratified the-Basel-Ban, and introduced legislation, to-control export of e-waste, to-developing-countries, *yet* thousands of tons of e-waste, still ends-up in-many-developing-nations. However, many-developing-countries, lack the-technology, facilities, and resources, needed to-*properly*-recycle and dispose of e-waste. For-example, only-few-developing countries have formal-e-waste-recycling-plants, including: China (Frazzoli *et al.,* 2010), India, Vietnam, (WHO, 2013), Pakistan, Malaysia, the-Philippines, Singapore, Sri-Lanka, Thailand (Lundgren, 2012) and Kenya (Seager, *et al.,* 2014). In-India and China, where more-complex-processes are employed, recycling practices include: manual-disassembly; heating printed-circuit-boards, to recover solder and chips; acid-extraction of metals, from complex-mixtures; melting and extruding plastics; and burning plastics, to-isolate metals (Lundgren, 2012). Majority of the-remaining e-waste, however, is recycled in the-*informal*-sector, typically characterized as being beyond the-reach of official-governance, unregulated, lacking structure, unregistered, and largely-illegal (Chi *et al.,* 2011).

West-Africa has largest-crude-e-waste *informal*-recycling-sites, in-Nigeria (Lagos) and Ghana (Accra, Agbogbloshie) (Lundgren, 2012; Seplveda *et al.,* 2010). *Informal*-e-waste-recycling is, often, home-based and family-run, consisting of *not* more than 15 individuals from, families, and communities, which dismantle e-waste, and have-made the-choice of poison over poverty (UNEP, 2013; The-Lancet, 2013). Some-e-waste-

workers are *not* fully, if at-all, aware of the-potential-health-risks, involved with e-waste-recycling. Among some-communities, e-waste-recycling is even-considered more-desirable, than scavenging, through *non*-electronic-waste. Much of the-informal e-waste-recycling done in-scrap-yards, homes, and is done by children.

According to Goodwill (2010), e-waste-recycling and disposal-operations, found in-developing countries, are more-likely to-use-methods, harmful to the-environment, damaging-human-health, by exposing people to-toxins. Pure-Earth (formerly Blacksmith-Institute) has ranked Agbogbloshie e-waste-dumping hot-spot, in-Ghana, as one of the world's 10 worst-toxic-threats (Blacksmith-Institute, 2013).

On-the-other-hand, the-main-components, of interest, for recyclers, are materials, containing: copper (wires and cables, CRT-yokes); steel (internal-computer-frames, power-supply-housings, printer-parts); plastics (housings of computers, printers, faxes, phones, monitors); aluminum (printer-parts); printer-toners; and printed-circuit-boards (Lundgren, 2012), among-others. For-example, in crude-recycling, e-waste is physically/manually dismantled, by using basic-tools, such-as: hammers, chisels, and screw-drivers. Printed-circuit-boards are heated, and components are removed. Gold and other-metals are recovered from the-stripping of metals, in open-pit-acid-baths. Plastics are chipped and melted, *without* necessary-protective-ventilation. Burning electrical-cables, often in open-pits, and at-relatively-low temperatures, to-retrieve copper, is one of the-most-common crude-recycling-practices (Chi *et al.,* 2011).

Currently, e-waste-scavenging provides a-source of livelihood, even-though a-dangerous-one, to-large-numbers of people, in-developing-countries (Oteng-Ababio, 2012; Pace, 2008). Poor-children and women, especially those, living in-urban-areas, represent a-large-portion of e-waste-recyclers (Chi *et al.,* 2011). Children are considered ideal-e-waste-workers, because they have small, dexterous-hands, which help them-easily-dismantle discarded-EEE (The-Lancet, 2013; Diaz-Barriga, 2013; Oteng-Ababio, 2012; Lundgren, 2012).

Additional-challenges include the-fact, that an-EEE-product usually multipart, it also-contains many different-materials, that are mixed, bolted, screwed, snapped, glued, or soldered, together. Besides, toxic-materials, are, often-joined, to-*non*-toxic-materials, which make separation of materials, for reclamation, difficult (Lundgren, 2012). Besides, end-of-life-computers often contain sensitive-personal information (e.g., bank-account-details), which, if exported, without being deleted, leave opportunity, for fraud/cyber-crime.

(e) Effects of improper-e-waste-management

E-waste is a-hazardous-waste (Tsydenova & Bengtsson, 2011), as many-electronic-products do-contain hazardous-compounds/materials (Greenpeace-International, 2007), having adverse-health and environmental-implications. Approximately 40% of the-heavy-metals, found in-landfills, comes from e-waste (Montrose, 2011); heavy-metals are well-known for their-harm to human-health and to the-environment. Various-forms of e-waste may also-include persistent-organic-pollutants (POPs), as-well-as chemical-elements, such-as: Barium, Mercury, Nickel, Zinc, Lithium, Chromium, and Beryllium, in their-components (Frazzoli *et al.,* 2010). For-example, the-key-chemicals, found at e-waste-recycling sites, in-Ghana, are: Lead; Cadmium; Phthalates; Antimony; PCBs (polychlorinated-biphenyls); Chlorobenzenes; PBDEs (polybrominated-diphenyl-ethers); and Triphenyl-phosphate (TPP), among-others (Brigden *et al.,* 2008). In-particular, CRTs (found in-older-desktop-computers and television-sets) contain the-greatest-amount (2-3kg) of lead, in-each-device. However, the-newer liquid-crystal-display (LCD)-screens contain a-mixture of 10-20 substances, in-each liquid-crystal, which are suspected to-be-hazardous (e.g., indium) (Tsydenova & Bengtsson, 2011).

According to Lundgren (2012); and EPA-US (2007, 2001), chemicals/compounds, of primary-concern, in e-waste, are: Antimony, Arsenic, Barium, Beryllium, Cadmium, Chlorofluorocarbons (CFCs), Cobalt, Copper, Dioxins, Gallium, Hexavalent-chromium, Indium, Lead, Lithium, Mercury, Nickel, Perfluorooctane-sulfonate PFOS/F, Phthalates, Polybrominated-diphenyl-ethers (PBDEs) used in brominated-flame-retardants (BFRs), Polychlorinated-biphenyls (PCBs), Polyvinyl Chloride (PVC), Silver, Thallium, Tin, and Zinc (chromates). For the-source(s) of each, of the-listed-compounds, in-electronic-products, and their-health-concerns, refer to-the-Annex I, in Lundgren (2012). For potential-effects on the-environment, of chromium VI (see Starovoytova, 2012), and of PVCs, see Starovoytova, 2018.

Direct-exposure, to-such-chemicals, occurs through: inhalation, dust-ingestion, dermal-exposure, and oral-intake. These-ruts are particularly-important in-human-exposure to: dioxins, lead, copper, cadmium, polybrominated-diphenyl-ethers (PBDEs), polychlorinated-biphenyl (PCB), chromium (Nimpuno & Scruggs, 2011), mercury, and other-metals and carcinogens (Lepawsky & McNabb, 2010). There is often a-lack of suitable-off-gas-treatment, during such recycling-processes, particularly smelting. Electrical-shocks are another-occupational-hazard (Prakash & Manhart, 2010). Individuals, who directly-engage in e-waste recycling, with-poor-protection, incur high-levels of direct, occupational-exposure (Chan & Wong, 2012; Chen *et al.,* 2010).

In-addition to-hazardous-nature of e-waste-constituents, several-*improper* e-waste-management practices were identified, in-the-previous-section, particularly, in-the-*informal*-sector, of the-developing countries; the-most-notorious being burning of electrical-cables. On-burning, the-immediate-environment, where people work and live, is overwhelmed with thick-black-toxic-smoke (Asante *et al.,* 2012), releasing heavy-metals (such-as: lead, cadmium, and mercury), polycyclic-aromatic-hydrocarbons (PAHs), polychlorinated-dibenzo-p-dioxins

and furans (PCDD/Fs), and dioxin-like polychlorinated-biphenyls (DL PCBs) (Frazzoli *et al.,* 2010), generated by *incomplete*-combustion, at low-temperatures. Besides, polystyrene-form, rubber, tires, crop-residue, or biomass, may be-used, as-fuel, for these-fires, and can-cause *additional*-harmful-exposures (Greenpeace, 2009). 'De-soldering' of circuit-boards, to-recover rare and precious-metals, can also-release lead-saturated-fumes. Toxic-substances can-also be-found, within the-following-types of emissions, or outputs: leachates, from dumping-activities; particulate-matter, from dismantling-activities; fly and bottom-ashes, from burning-activities; fumes, from mercury-amalgamate 'cooking', de-soldering and other burning-activities; waste-water, from dismantling and shredding-facilities; effluents, from cyanide-leaching, and other-leaching-activities (Sepúlveda *et al.,* 2010).

Crude-recycling, or improper-disposing-off e-waste, can pose serious-threats to-human-health and the-environment (Santillo *et al.,* 2007). For-example, POPs, aluminum, mercury, manganese, and lead, affect children's neurological-development, while chromium, arsenic, and PAHs, increase the-risk of cancer. Furthermore, POPs and DL-PCBs have-been-classified as endocrine-disruptors (NIEHS, 2011; Frazzoli *et al.,* 2010), which interfere with the-body's endocrine, or hormone-system, and may-result in-undesirable effects, experienced in the-neurological, immunological, and reproductive-systems, e.g., reduced-fertility (NIEHS, 2011). Besides, inhalation and dust-ingestion impose a-range of potential-occupational-hazards, including *silicosis* (Lepawsky & McNabb, 2010).

As mentioned earlier, in-this-paper, majority of workers, in informal-e-waste-recycling-sector, are children. Chemicals can-accumulate in-children's bodies, because their-immature-systems are unable to-effectively-process and excrete some-toxic-materials (Norman *et al.*, 2013; Suk *et al.,* 2003). The-Basel-Action-Network, for-instance, pointed-out, that the-poorest-people, in-many-cases children, are put to-work dismantling e-waste, with *no* safety-measures, exposing themselves to-highly-toxic-chemicals, including mercury, which damages the-brain; lead, which can damage reproductive-systems; and cadmium, which causes kidney-damage, among-others. In-particular, in-China, there has been a-surge in-cases of child-leukemia, and high-concentrations, of lead, in-blood of e-waste-recyclers (Tsydenova & Bengtsson, 2011). WHO (2012), expressed a-particular-concern on the-exposure of children and pregnant-women to heavy-metals, as even relatively-low-levels, of exposure, can cause serious and, in-some-cases, irreversible neurological-damage, intellectual-impairment, and attention-difficulties, in-children, and threaten the-development of the-unborn-child. Besides, irreversible-cognitive-deficits, in-children, and potential behavioral and motor-skill-dysfunction, across their-lifespan, was reported (Chen *et al.,* 2011).

An-additional-source of *indirect*-exposure is so-called *'take-home-exposure'*, which is a-second-hand-exposure, to hazardous-substances incurred, especially by children, when the-traces of harmful-substance, is brought-into the-home on contaminated-with harmful-residue from e-waste-recycling, on clothing, materials, or other-objects (Horton *et al.,* 2013). Take-home-exposure has the-capacity to-cause low-level, chronic, and long-term-exposure. For-example, particulate-matter, from e-waste recycling-areas, can lead to-inflammatory-response, oxidative-stress, and DNA-damage (Yang *et al.,* 2011).

Furthermore, studies, conducted in-China and in-India, indicate that hazardous-substances, from e-waste, can-extend beyond processing-sites, and into-ecosystems (Sepulveda *et al.,* 2010), through contamination of soil, air, and water, around e-waste-recycling-sites. POPs-ecological-exposure, due-to their-persistent-nature, have long-term, and widespread, health-risks (Seplveda *et al.,* 2010). Many of the-indicated-above-chemicals, in-addition to-their adverse-effects, are prone-to bioaccumulation and often resist biodegradation (Frazzoli *et al.,* 2010). Furthermore, biomagnifications of such-chemicals, are often amplified, in-food-sources, and are able to-be-passed, from mother to child, *via* breastfeeding. A-lack of health-care-services and resources, often-experienced in-developing-countries, typically results in the-inability to-mitigate the-serious-health-consequences of e-waste (Musmeci *et al.,* 2010; Sonak *et al.,* 2008).

3.2. SWM: Challenges

UNEP & ISWA (2015) published the-first-comprehensive global-overview (the-GWMO), of the-state of WM, around the-world, in the-21st Century. The-GWMO estimates, that around 2 billion-people, worldwide, still lack access to-regular waste-collection; while around 3 billion, lack access to-controlled-disposal services for MSWs. This-reality is a-global-public-health and environmental-imperative, requiring a co-ordinate-approach, rather than just a-national or local-problem (WM &R, 2015). The-high population-growth, as a-contributing-factor, to-SWM-problems, was reported by Zurbrugg (2003); Medina (2002); the-World-Bank (2005); and Schubeler *et al.* (1996), among others. Besides, UN (2014), revealed, that more-than 50% of the-world-population, already-reside in-the-urban-areas (in-both; developed and developing-countries), and this-figure is expected to-rise.

In-addition, the-illegal transnational-flow of toxic, hazardous, radioactive, and e-waste, is now recognized to-be-one of the-most-significant-forms of transnational-crime, operated by criminal organizations, worldwide (Greenpeace, 2010; UNODC, 2009). According to Rucevska *et al.* (2015), as any-other-illicit-activity, illegal-waste-disposal is likely-to-happen in-the-presence of weak-environmental regulations, poor-law-enforcement,

and where local-populations are *not* informed on the-consequences of the-exposure to toxic-substances. Many-developing-countries, hence, become the-ideal-destinations, for dumping, of such-wastes, produced, largely, in-developed-countries (Gennaioli & Narciso, 2017). Such-situations is posing an-environmental and health-hazard, if *no* system is put-in-place, for handling-such-wastes, in-environmentally-sound-manner. In-any-developing-country, the-threats, posed by improper-handling and disposal, of solid-wastes, often ignored, contribute to the-high-level of mortality and morbidity (Medina, 2002).

WM-problems, in-Africa, in-particular, are varied and complex, with inadequate-funding for WM, infrastructure, political, technical, social/economic, organizational/management, regulatory and legal-issues and challenges, to-be addressed. Sub-Saharan-African-countries, score lower, than any-other-region, at Environmental-Performance-Ranking (EPI, 2018), occupying 30 of the-bottom 44 positions. Rising populations in sub-Saharan-Africa continue to-put considerable-demands on limited-environmental resources. The-UN estimates, that about half of the-population, in-sub-Saharan-Africa is living on less-than a-dollar a-day, making it the world's poorest and least-developed-region. The-number of people, living in-slums, often without access to-basic-services, is expected to-double, to-approximately 400 million-people, by 2020, putting even-more pressure on these-resources (UN, 2014). A-major-concern is that there are *no* adequate-infrastructural-facilities, and appropriate-land-use-planning, to-match-up with-the-demands, posed by the-urban-growth-rate, especially the-slums and 'ghettos', in-Africa (Pichtel, 2005). Higher-SWM performance, in-sub-Saharan-Africa, is still-possible, e.g. Seychelles and Namibia, both; making significant-progress, on-certain issue-categories. Seychelles scored 39th in the-overall-rankings and 1st in-SSA, while Namibia (79th) improved, its-Biodiversity & Habitat-score, significantly, over the-past-decade, ranking 11th in-the-category, globally (EPI, 2018; Conniff, 2011).

Besides, Achankeng (2003) pointed-out on the-rise of specific-problems, in-developing-countries, where according-to Senkoro (2003), 30-50% of populations are urban. The-problems are: congestion, increased-volumes of traffic, on poorly-maintained-roads, inadequate-housing and services, increased-level of pollution, and poor-WM. Furthermore, *informal*-settlements, bringing their-own set of challenges, are also on-the-rise, according to Marshall & Farahbakhsh, (2013); UN-Habitat (2014); and Henry *et al.* (2006). For-example, informal-settlements-structures serve both; as residential and small-business-enterprises (Gutberlet *et al.,* 2003), bringing in massive-congestion. Due-to congestion and very-narrow-roads, garbage-trucks have *no* access, to many-areas, hence, leaving the-*only*-option, for waste-transportation, *via* human-drawn-carts, barrows, and, even, human-backs (UN Habitat, 2014; Schubeler, 1996). Furthermore, according to UNEP (2005), in-developing-countries, waste-handling is considered "below acceptable level of dignity".

In-many-developing-countries, SWM is usually characterized by: low-spatial-coverage of waste-collection; inefficient-collection-methods; lack of appropriate SWM-technologies and infrastructure; inadequate-financial and technical-resources; improper-disposal; pollution from uncontrolled-dumping; limited-data, on waste-generation; and lack of public-awareness and participation, in-WM (Njoroge *et al.,* 2014; Tan, 2012; Baabereyir, 2009). Besides, waste is typically disposed-off, *without* any-consideration for environmental and human-health-impacts, leading to-its-accumulation, in-cities, towns, and uncontrolled dumpsites. Co-disposal of non-hazardous and hazardous-waste, *without*-segregation is a-common-practice (Ekere & Mugisha, 2009). Overall, WM, in the-region, suffers from limited-technological and economic-resources, alongside with poor-funding, which jointly result in the-prevalent low-standards of WM (Zurbrugg & Ahmed, 2000). This is intensified by public-perception of waste-disposal as-a-welfare service-issue, and therefore, the-unwillingness to-pay for waste-disposal, especially among-the-poor (UNIDO, 2009).

Moreover, the-management of *municipal*-solid-waste is beyond the-capacity of most-urban-areas, resulting in dumping of waste in undesignated-sites. Urban-governments, in many-African-countries are facing serious-problems with SWM; solutions, developed for the-developed-countries are often *not* appropriate to-contexts in the-developing-countries (UNEP, 2005; World Bank, 2005). Additionally, technical-factors, influencing the-SWM-system are related-to: lack of technical-skills, among personnel, within-municipalities and government-authorities (Hazra & Goel, 2009), deficient-infrastructure (Moghadam, 2009); poor-roads and vehicles (Henry, 2006), insufficient-technologies, and lack of reliable data (Mrayyan & Hamdi, 2006). For-example, Ogbaji & Kunene, (2008) stated, that WM-infrastructure is largely-collapsing or, even, nonexistent, in most-institutions, in-Africa. Matete & Trois (2008), also-suggested the-factors, affecting the-environmental-aspect of SWM, in-Africa, such-as: the-lack of environmental-control-systems and evaluation of the-real-impacts. The-huge-expenditure needed to-provide the-adequate-service; the-absence of financial-support; limited-resources; the-unwillingness of the-users to-pay, for the-service; and lack of proper-use of economic-instruments, have hindered the-delivery of proper-WM-services (Ekere & Mugisha, 2009; Schübeler, 2006). In-addition to budgetary constraints/insufficient-funding for SWM, funds-mismanagement and embezzlement, was also-reported (Da Zhu *et al.,* 2008; Henry, 2006).

4. Discussion.

4.1. Analysis of generation-rates.

From the-analysis of section 1.1.2., it can be pointed-out, that solid-waste-generation-rates vary-widely, within and between-countries, while SW-generation, per-capita (ranging, in-2012, from an-average of 0.45 kg/capita/day to 2.2 kg/capita/day), is strongly-correlated-with national-income (GDP).

Non-stoppable and fast-growing-urbanization, rapid-socio-economic-development, and advancements in-human-health (Ogbonna *et al.,* 2007; Walsh *et al.,* 2006), associated-with industrialization, advances in-science and technology, population-growth, changing-lifestyles and rising standards of living, alongside-with increasing purchasing-power/disposable-incomes of growing-middle- class (Gakungu *et al.,* 2012; Sharholy *et al.,* 2008), the-increase in-consumption and in-variety, of different-goods and services, changing consumption-patterns and eating-habits (Ngoc & Schnitzer, 2009), have resulted *not* only in grammatically-increased-solid-waste-generation, *but* also in-heterogeneity, and composition-complexity, of the-waste-streams, generated (Guerrero *et al.,* 2013; UNIDO, 2009; Periathamby *et al.,* 2009).

Future-projections estimate that, the-world's waste-production could reach up-to 27 billion-tons, by 2050 (VES, 2006). The-amount, generated by developing-countries, accounts for *only* 5% of the-world's-total-waste (World-Bank, 2012), however, waste-generation is expected to-increase significantly, as a-result of population-growth, industrialization, urbanization, and modernization of agriculture. This will further-aggravate the-currently-existing capacity-constraints, in-WM, in-developing countries (UNIDO, 2009). According to UNDEA (2008), most of the-population-growth will-be concentrated in-developing-countries. The-urban-population, in-Africa, is projected to-treble from 470 million, in-2015, to 1.2 billion in-2050, making Africa the-continent with the-highest urban-population growth (UN, 2013). 62% of urban-populations, in-Sub-Saharan-Africa, live in-slum-areas, dominated by uncontrolled-informal-spatial-developments, most-often-located in environmentally-fragile-areas, and *without* access to-basic-services, such-as: water, sanitation, energy, transport, and WM-systems (UN-Habitat, 2014).

Global-waste-generation is expected to-increase-further, significantly, due-to raising-population growth, rapid-development and an-increase of national-GDP (particularly in-China and India), and ever-growing-urbanization and development of Mega-cities (particularly in-Africa), among other-factors.

4.2. Analysis of SWM-practices

Examination of SWM-practices showed clear-differences in-WM-systems, between developed and developing-cities. For-instance, WM-practices, in-developed-cities currently-focus on optimization strategies, for resource-conservation (Wilson, 2007; McDonough, 2003), whilst approaches to-WM, in-developing-cities are often-underdeveloped (Badgie *et al.,* 2012), operationally-inefficient, and inadequately-managed, with limited-knowledge and expertise, to-hand (Zurbrügg & Schertenleib, 1998). Overall, in-developed-countries the-main-consideration, in-SWM, is resource-value of the-waste, which is, often-described as a-potential-shift, from 'waste-management' to 'resource-management', with complementary-policy-initiatives, such-as sustainable-consumption and production (SCP), the 'circular-economy', and the 'green-economy'. In-developing-countries the-major-emphasis is still, put on SW-*collection,* as low and middle-income-countries/cities still face major-challenges in ensuring *universal*-access-to waste-collection-services. Besides, the-differences in-efficiency of WM, between developed and developing-countries, remain wide, despite expenditures, which are comparable, or similar. Low-income-countries spend most of their-expenditure on waste-*collection*, rather than disposal, while developed-countries emphasize on reduction, and segregation, at-source. From the-analysis of the-SWM practices, the-level of country's-income directly-affect the-average waste-collection-coverage (ranging from 36%, in low-income-countries, to 100% in-high-income-ones). In-developing-countries, the-collection-coverage is vary-widely, for-example, in-Africa (25-70%) and in-Asia (50-90%) (Badgie *et al.,* 2012). This could-be-attributed to the-large 'rich-poor-gap', in-these continents/countries/cities, where slums/informal-settlements are largely-ignored, due-to their-illegal-status and lack of political-voice, and even in the-upper-class-areas the-waste-collection is *yet* to-reach a-complete-coverage.

WM is a-basic-human-need and can also-be regarded as a 'basic-human-right'; ensuring proper-sanitation and SWM, stands-alongside the-provision of potable-water, shelter, food, energy, transport, and communications, as essential to-society, and to-the-economy, as a-whole. Despite this, the-public and political-profile of WM, is often lower-than other-utility-services, particularly-so, in-many-developing-countries (GWMO, 2015).

SWM is one of the-major-challenges, worldwide. According to Zerbock (2003), SW was identified, by-African-countries, as the-second-*most-important*-problem, after water availability and quality. Identifying a-problem is a-first-step in finding possible-solutions to-it. SWM is generally-considered an 'urban'-issue, facing many-challenges (see section 3.2). The-problem is further-complicated-by rapid-population-growth, urbanization, corruption, low-awareness on the-potential-hazards, associated-with improper-waste-management and disposal, the need to-prioritize other-services (such-as health-care and education) and lack of environmental-

values (Kuniyal *et al.*, 2004; Zerbock, 2003).

On-the-other-hand, the-public-health and environmental-damage costs of uncollected-waste, uncontrolled-disposal, open-burning, and unsound-resource-recovery, include: additional-health-care costs, lost-productivity, flood-damage, damage to businesses, and tourism-sector, and longer-term clean-up costs. Measuring these 'intangible' costs is complicated, *but* the-evidence, collected suggests, that the-economic-costs, to-society, of inaction are 5-10 times greater-than the-financial-costs of proper-WM (WM&R, 2015). GWMO (2015), in-the-same-accord, stated, that it-is significantly-cheaper to-manage waste now, in an-environmentally-sound-manner, than to-clean-up, in-future years the 'sins of the-past'.

Besides, UNEP-Annual-Report (2005), pointed-out, that in-many-developing-countries, the-greatest-impediments to-efficient and environmentally-effective-handling of SW, are managerial, rather-than technical. Improving the-operational and management-capabilities, of individuals and institutions, involved in-SWM, at-the-local-level is, therefore, paramount.

Many-international-organizations are involved in-trying to-improve the-status of SWM, in-developing-countries. For-example: UN-Habitat's response, to-the-urban WM-challenge, in-Sub-Saharan Africa, aims at tackling the-multi-dimensional-nature of the-challenge. UN-Habitat has also been-working with local-governments and communities on WM-approaches that are: participatory and all-inclusive; tailor-made to-local-conditions; innovatively-designed and low-cost-equipment, which are preferably developed-locally, in-order-to-ensure availability of after-sales-services, within the targeted-region; incorporates income-generation; and encourages the-full-involvement of local-communities, for job-creation. The-approaches involve: Knowledge-generation and global-advocacy, Innovative and appropriate-technologies, Programmatic and holistic-responses to-improving WM-services, in-slums, through the-Participatory-Slum-Upgrading-Program (PSUP) (UN-Habitat, 2014).

4.3. Analysis of Legal-foundation

Internationally, the-importance of SWM has been-recognized, *via* its-inclusion within the-UN-Sustainable Development-Goals. Goal 11 (*'Make cities and human settlements inclusive, safe, resilient and sustainable'*) target 7, seeks to-reduce per-capita adverse-environmental-impacts, through paying-attention to 'municipal and other waste-management'. Moreover, Goal 12 ('Ensure sustainable consumption and production patterns') also includes targets for: food-waste-minimization (12.3); environmentally-sound waste management-processes (12.4); and reduce waste-generation through: prevention, reduction, recycling, and reuse (12.5).

Besides, Figure 2 shows the-time-frame/chronology of the-relevant, to-SWM, International Conventions, Protocols, and Agreements (highlighted in-section 2).

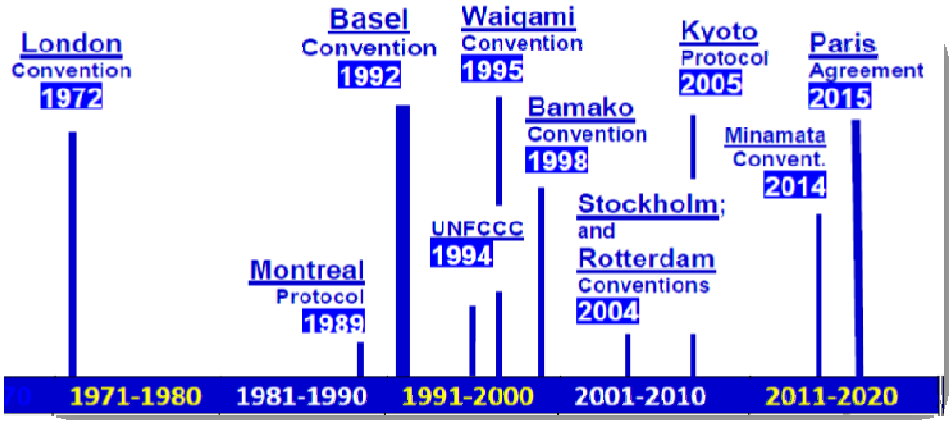

Figure 2: Chronology of the-relevant, to-SWM, International legal-documents.

Figure 2 also illustrates that there are, indeed, numerous-International-laws, relevant-to SWM. The-analysis of the-same, revealed, that:

The-interpretation that the-London-Convention did *not* include dumping *under* the-seabed was at-best, uncertain. Therefore such-practices are still conducted, including illegal-dumping, under the-seabed, of radioactive/nuclear-waste.

On-the-other-hand, the-Montreal-Protocol, within 25 years of signing, celebrates significant-milestones: the-world has-phased-out 98% of the-Ozone-Depleting-Substances (ODS), contained in-nearly 100 hazardous-chemicals, worldwide; every-country is in-compliance with stringent-obligations; and, the-protocol has-achieved

the-status of the-first-global-regime, with *universal*-ratification; even the-newest-member-state, South-Sudan, ratified it, in-2013. UNEP received accolades, for achieving global-consensus that 'demonstrates the world's commitment to ozone protection, and more-broadly, to global environmental protection' criminal-justice, through the-International Criminal-Court (ozone.unep.org).

According to Lipman (2000), "The Basel Convention is an-important first-step in achieving environmental justice for developing countries. Admittedly, it falls short of this objective in a number of respects". He also-stated, that, while the-Basel-Convention has-been-ratified, by most-industrialized countries, the-United-States has *not* yet become a-party to the-Convention. The-United-States is the world's largest-generator of hazardous-wastes, accounting for almost 75% of the world's annual-production (Greenpeace, 1994). Consequently, to-ensure environmental-justice, for developing-countries, the-participation and co-operation, of the-United-States, is paramount. Kitt (1995), clarified, that the-United-States, *did* sign the-Basel-Convention, in-1988, and Senate consented to its-ratification, in-1992. However, the-instruments of accession have *not* been deposited, with the-Basel-Secretariat, as the-US-Congress has *not* yet passed *domestic*-legislation, to-implement the-Convention. Domestic legislation is essential, to-enable the-United-States to-meet its-obligations, under the-Convention. For-example, without-such-legislation, federal-agencies would-be-unable to-prevent exports, to a-non-party, or to re-import-waste, which has-been-exported, in violation of the-principles of environmentally sound-management. In-addition, the-Convention lacks an-enforcement-mechanism to-ensure that hazardous-waste-traders are fully-accountable, for all-damages, occurred. Another-limitation, and a-big-one, is that, the-provision for separate-agreements, under Article 11, and the-loopholes, which it provides, permits hazardous-waste-exports, for *recycling*.

In-contrast, the-Bamako-Convention, Article 4.1., imposes a *total* ban on nuclear and hazardous-waste-imports, into-Africa, for final-disposal and recycling. Some-African-countries have taken a-very-serious-stand on hazardous-waste-dumping; e.g., Nigeria and Cameroon have imposed the-death-penalty, for such-waste-importers (LA-Times, 1994). It-is interesting to-note, however, that the-ban, on-exports of hazardous-waste, to-developing-countries, does *not* apply to-exports, from *other*-developing-countries. Consequently, a non-OECD-country, could conclude a-bilateral-Agreement with-another non-OECD-state, to-receive hazardous-waste (Lipman, 2000).

International-law, especially international-environmental-law is often-criticized for its-*non*binding-effect. Some-legal-scholars explain that the-soft-law-aspect, of this-discipline, is important, to-have a-meaningful-impact in international-relations. In-this-regard, within the *Minamata Convention on Mercury,* new-instruments have been used; a 'Mercury-Club' was established, to-support the-negotiating process, for the-*legally*-binding instrument on-mercury. In-addition, three-different-types of awards, gold, silver and bronze, were presented, and established; Gold - contributions of USD 1,000,000 and more; Silver - contributions of USD 500,000 and more; and Bronze - contributions of under USD 500,000. The-recipient of award included: governmental-bodies, intergovernmental-organizations, non-governmental organizations, and individuals.

In-many-developing-countries, the-implementation of the-laws, regulating trans-boundary movement of waste, is *not* a-national-priority (Obradovi *et al.,* 2014). Across Africa, the-legal and institutional/administrative-framework, for the-environmentally-sound-management of waste is, either lacking, or inadequate. *Not* all the-countries have ratified the-Multilateral Environmental-Agreements (MEAs) on wastes and chemicals (in-particular: the-Basel, Stockholm, and Rotterdam Conventions). *Comprehensive*-national waste-legislation is lacking, although several-countries have piece-meal-legislation on hazardous-WM (UNIDO, 2009).

In-particular, UNIDO (2009), in-its Africa-review-report on WM, pointed-out, that: (1) Most (but *not* all)-African-countries have-ratified the-relevant-international-instruments for hazardous-waste (including Basel and Bamako-Conventions) and are at-different-stages with development and implementation of nation-action-plans for implementation; (2) The-absence of specific-financial-instrument and other-means of implementation, complementary to the-Regional-Centers, under the-Basel-convention has hindered full-implementation of the-Basel-convention; (3) Only 23 (out of 54) countries had-ratified Bamako-Convention (by September, 2007). The-convention prohibits the-import of hazardous-materials into-Africa, *but* lacks means of implementation and so-far *no* Conference of the-Parties has-taken-place; (3) Protocol on liability and compensation for damages is *still* under- discussion, among the-Parties; (4) Most-African-countries still need to-prepare inventories of hazardous-wastes and sites, potentially-affected, through inappropriate-disposal of hazardous-wastes; (5) Management of trans-boundary-movement of hazardous-waste, including illegal-trafficking is now governed by the-Basel and related-conventions, which have-been-ratified and are being implemented, across-Africa. There is, however, a-need to-strengthen trans-border-controls and policing of waste-transports; (6) Revenue-authorities should-also-be involved in implementation of these-agreements; (7) There is widespread and growing-concern about the-growing imports of used-consumer-goods, that contain hazardous-materials (e.g., electronic and electric-products, cars, medical-equipment, pharmaceuticals, etc.,). The-ultimate-disposal, of these-hazardous-materials, contained in-the-consumer-goods, poses serious-ecological and health-threats. Some-African-countries have moved to-ban imports of used-consumer-goods; (8) Mining of various-minerals is widespread,

around-Africa. The-management of radio-nuclides, mined either intentionally (uranium) or as by-product (e.g., gold; cobalt, etc.) is of concern; (9) Most-African-countries import products, containing radio-active materials (e.g., medical-applications) and the-management of such-waste is of concern; (10) There is still a-need to-comprehensively-identify site, that potentially-have-been-contaminated with radioactive-wastes, in-Africa; (11) While African-countries acknowledge the-importance of sound-management of radio-active wastes, the-capacity to-do-so remains still very-low, across-Africa, as *only* few-countries (e.g., Egypt) have-given-priority to-develop and implement comprehensive-radio-active WM-systems.

In-addition, according to UNIDO (2009), the-gap, between waste-management (WM)-policy and legislation, and *actual*-WM-practices is expanding, owing to continuing-capacity-limitation, and/or non-existence of WM-facilities, for the-different waste-streams. Resolving this-capacity-gap will-require major-investments and access-to technical-know-how. The-means, for accessing these, in-developing countries of Africa, however, are far-fetched.

Moreover, often it is *not* the-environmental-legislation, itself, that is at the-heart of the-problem; rather, it-is the-lack of their-enforcement, and widespread-*non*compliance, that is the-real-challenge, to sustainable-WM (Al-Khatib *et al.,* 2010). The-above-analysis points-out on current-challenges in-implementation/enforcement of the-listed-treaties. In-this-regard, the-developed-countries should strictly implement/enforce the-relevant international-Agreements/Conventions on WM (particularly Basel, and Bamako), and provide assistance to-still-developing-countries to-strengthen their-national-human and institutional-capacities, for implementation and enforcement (especially for control of imports and exports of wastes into and within-the-region). It-is also-important, for the-rest of African-countries, which have *not* yet ratified the-relevant-international instruments, for hazardous-waste, to do so. Such-implementation will *not* only reduce the-impacts of uncontrolled-waste-disposal, on human-health and the-environment, but also assist in-achieving the-goals of the-Cotonou-Agreement (aimed at the-reduction and eventual-eradication of poverty, while contributing to-sustainable-development, and to-the-gradual-integration of ACP-countries, into-the-world-economy). The-Cotonou-Agreement is a-treaty, between the-European Union, and the-African, Caribbean, and Pacific-Group of States ('ACP-countries'). It-was-signed in-June, 2000, in-Cotonou, Benin's largest-city, by 78 ACP-countries (Cuba did not sign) and the-then 15 Member-States of the-European-Union. It entered into-force, in-2003, and was subsequently-revised, in-2005 and 2010.

Furthermore, to-achieve an-effective WM-system, in-addition to the-implementation of international-treaties, three-categories of policy-instruments, should be-used, in a-coherent-mix (Bengtsson *et al.,* 2010; Gunningham, 2009; Braathen, 2007; Gonzenbach & Coad, 2007; Howlett & Rayner, 2007): (a) '*direct-regulation*', comprising legislation, accompanied by its-keen-enforcement; (b) *economic* instruments, providing incentives and disincentives, for specific-waste-practices; and (c) '*social*' instruments, based on communication, and interaction, with-stakeholders. 'Direct-regulation' 'command and-control'-approach, is a-policy-instrument, which relies-on the-legitimacy, authority, and sanctioning power, of the-state, for establishing rules of conduct, or procedure, through legislation, and inducing consent and compliance, through-implementation, including enforcement *via* criminal and civil-sanctions. While monitoring, inspection, and enforcement, tend to-be-costly, in-terms of institutional capacities, required, 'direct-regulation' will-remain a-preferred-policy-instrument, in-situations, involving high-risks to-society and serious-consequences of *non*-compliance, such-as the-improper-handling of hazardous-waste. *Economic-instruments,* for-example, a pay-as-you-throw (PAYT) charging-system for residual (mixed) waste, will-reward people for segregating their-waste; taxes on land-filling or incineration, will-discourage opting for these-methods. '*Social*' instruments, on-the-other-hand, rely on communication, awareness raising, and interaction, between the-government-institutions and the-public, and other-stakeholders.

4.4. Examination of Illegal-dumping of wastes

4.4.1. Radioactive-waste from nuclear-power-plants, and solar-energy-potential, in-African-region.

Previous-section 3.1.1 showed selected-examples of illegal-dumping, including illegal-dumping of radioactive-waste and the-consequences to human-health and the-environment. Majority of radioactive-waste is generated from nuclear-power-plants. According to World Nuclear Power, nuclear power-stations operate in 31 countries. China has 32 new-reactors, under-construction, and there is also a-considerable-number of new-reactors being-built in South-Korea, India, and Russia. At the-same-time, at-least 100 older and smaller- reactors will "most probably be closed over the next 10-15 years" (Dittmar, 2010). So the- expanding-nuclear-programs, in-Euro-Asia, are balanced, by retirements, of aging-plants, and nuclear-reactor phase-outs (Diesendorf, 2013).

After Japan's Fukushima-nuclear-disaster, in-March 2011, Germany has-permanently shut-down 8 its-reactors, and pledged to-close *all*-the-remaining, by 2022. Likewise, Nuclear-Referendum, in-Italy, in-2011, showed overwhelming-support, by Italians, towards keeping their-country *non*-nuclear. Switzerland and Spain have banned the-construction of new-reactors (Sokolski, 2011). Japan's prime-minister and Taiwan's president have called for a-dramatic-reduction in-their-reliance on-nuclear-power (Inajima & Okada, 2011). Mexico has sidelined construction of 10 nuclear-reactors, in-favor of developing natural-gas fired-plants (Rodriguez, 2011).

Belgium is considering phasing out its-nuclear-plants, completely, by 2015. As of 2012, countries such-as: Australia, Austria, Denmark, Greece, Ireland, Italy, Latvia, Liechtenstein, Luxembourg, Norway, Portugal, Israel, Serbia, Malta, and Malaysia, have *no* nuclear-power reactors, and remain-opposed to-nuclear-power (Fertl, 2011).

South-Africa, so-far, is the-*only*-country, in-Africa, with a-commercial nuclear-power-plant, and it currently has an-expansion-policy. Ghana has research-reactors, but *no* power-plants; the-government of Ghana plans to-commission the-building of a-nuclear-power-plant, by 2018 (Daily Guide, 2008). Since 1995, Algeria operates research-reactors, at Draria and Aïn-Oussera. It signed nuclear cooperation agreements with Russia, in-January 2007, with the-United-States, in-June 2007, and with-China, in-March 2008. Algeria has discussed nuclear-cooperation also-with France (World Nuclear News, 2008). In-2010, Libya confirmed, that it intended to-create a nuclear-energy-sector (World Nuclear News, 2010). Morocco constructs a 2 MW Triga-research-reactor. The-government has plans to-build a-nuclear-power-plant, in-2016–2017, at Sidi-Boulbra, in-cooperation-with Russia's Atomstroyexport (World Nuclear Association*, 2009).* Nigeria began-talks with the-Russia's state-owned-company Rosatom, in-April 2015, to-collaborate on the-design, construction, and operation of 4 nuclear-power-plants, by 2035, the-first of which will-be operational, by 2025 (*Burite, 2016).* According to Nuclear Threat Initiative, Egypt signed, in-March 2017, preliminary-agreements with-the-same-Russian nuclear-company, for a-first VVER-1200 unit, at El-Dabaa, to-start in-2024; discussions continue for-final-approval. *The-East-African* reported, that in-2017, the-Kenya-Nuclear-Electrification-Board (KNEB) estimated that a 1,000 MW nuclear-power-plant, of South-Korean-technology, could-be-operational, by 2027, at a-cost of KES 500-600 billion (USD 5-6 billion) (The-East- African, 2017). The-plant will generate about 19% of Kenya's energy-needs; positioning nuclear-power as the-second-largest-source of energy, in-Kenya, after clean-geothermal-option (Bloomberg, 2010).

Instead of going green/clean/renewable (for-example solar-energy will be a-more-logical-solution, in-tropical-climates of Africa), many-African-countries making plans to-acquire inherently-dangerous nuclear-power-reactors. The-following-sections will elaborate on the-potentials of renewable-energy, in the-context of ever-growing-energy-demand.

Africa's population is set-to-double, by 2050, and its-energy-needs will-grow even-faster. If current-growth-rates are maintained, Africa's GDP will-increase seven-fold, by 2050. The-International Energy-Agency (IEA), in-2014, estimated, that overall, about 620 million-people, in-Africa, representing two-thirds of the-continent's population, do *not* have-access to-electricity (IEA, 2014). In-several-countries, (Mauritania, Guinea, Burkina-Faso, Niger, Chad, Central-African-Republic, D. R. Congo, etc.) more-than 75% of the-population has *no* electricity. With 15% of global-population, Africa remains *the-most* energy-poor-region, in-the-world, contributing just about 2.4%, of global-GDP (IEA, 2014). According to the-United-Nations-Human Settlements-Program, it was projected, that in-2030, there will-still-be 655 million-people, in-Africa (42% of the-population) without access-to-power (UNHSP, 2010).

The-power-utilities, in-Africa, have clearly failed-to-provide adequate-levels of electricity-services, to the-majority of the-region's population, especially to-rural-communities, and the-urban-poor. Sub-Saharan-Africa-experiences very-low-levels of access-to-electricity, with the-highest-levels recorded in-South Africa and Mauritius (66% and 100%, respectively) (Karekezi & AFREPREN, 2003). Secondly, according-to Figure 3, Africa heavily-relies on-thermal-power, for the-electricity-generation; utilizing very-little (*if at all*) renewable-options.

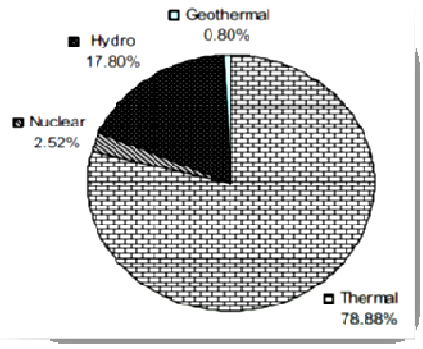

Figure 3: Electricity-production, in-Africa, 2004 (IEA, 2005).

Access-to-energy is a-pre-requisite of economic and social-development, for any-country; industrialization is *unattainable* without access to-sufficient and reliable-power. In as-many-as 30 African-countries, however,

recurrent-electricity-outages and load-shedding, is the-norm (IEA, 2014). The-World-Bank (2013), estimates, that African-manufacturing-enterprises experience power-outages, on-average, 56 days, per-year. On-average, number of power-outages, in-SSA-region, is 8.3 times/month, each lasting for 5 hours/outage (IEA, 2014).

Providing full-electricity-access, to *all*-Africans, will require at-least a-doubling of total-electricity-production, by 2030, from current-levels (IRENA, 2014). This-ever-growing-demand probably was the-biggest-trigger for African-governments to-look at nuclear-power, as a-potential-solution.

On-the-other-hand, on 5th December, 2012, the-United-Nations General-Assembly (UNGA) declared the-decade 2014-2023 to-be the 'United Nations Decade of Sustainable Energy for All' (SE4ALL), by 2030: (i) Ensuring universal-access to modern-energy-services; (ii) Doubling the-global-rate of improvement in energy-efficiency; and (3) Doubling the-share of renewable-energy in the-global energy-mix.

Renewable-energy refers to-energy-forms, which can*not* be easily-depleted. Renewable-energy sources occur naturally, and encompass energy-forms, such-as: wind, solar, hydro, biomass, geothermal, tide, and wave-energy (Energy-sector in-Africa, 2007). Africa's energy-sector is best-understood, as 3 distinct-regions; (1) North-Africa, which is heavily-dependent on oil and gas; (2) South-Africa, which depends on-coal; and (3) the-rest of Sub-Saharan-Africa, which is largely-reliant on biomass (Karekezi, 2002a). Africa has substantial-renewable-energy-resources, most of which, however, are under-exploited. Renewables can play a-transformative-role in-the-African-energy-mix, enhancing countries' energy-self sufficiency, by-limiting their-dependence on fossil-fuel-imports (IRENA, 2014).

Only 3 renewable-energy-sources (i.e., biomass, geothermal, and solar) can-be utilized, to-yield *sufficient*-heat-energy, for power-generation. Of these-three, solar-energy exhibits the-highest global potential, since geothermal-sources, are limited to a-few-locations, and the-supply of biomass is *not* ever-present, in-nature (Sampaio & González, 2017; Holm-Nielsen & Ehimen, 2016). Solar-energy is one of the-best-options, to-meet future-energy-demand, since it-is superior, in-terms of availability, cost-effectiveness, accessibility, capacity, and efficiency, compared to-other renewable-energy-sources (Green *et al.,* 2016; Kannan & Vakeesan, 2016; Energy-sector in-Africa, 2007).

The-sun is a-major-source of inexhaustible-*free*-energy (solar-energy) for our-planet-Earth (Kabira *et al.,* 2017). Theoretically, solar-energy possesses the-potential, to-adequately-fulfill, the-energy-demands, of the-entire-world, if technologies, for its-harvesting and supplying, were readily-available (Blaschke *et al.,* 2013). Nearly 4 million ExaJoules (1 EJ = 1018J) of solar-energy reaches the-earth, annually, 5 × 104 EJ, of which, is claimed to-be easily-harvestable (World-Energy-Outlook, 2012). The-average-amount of solar-energy, received at Earth's atmosphere, is around 342 W m^{-2}, of which 30% is scattered, or reflected-back, to-space, leaving 70% (239 W m^{-2}), available for harvesting and capture (Hart, 2015). The-annual effective-solar-irradiance varies from 60 to 250 W m^{-2} worldwide (Luqman *et al.,* 2015).

Solar-energy is both; sustainable, and renewable, hence, it will *not* be depleted (Görig & Breyer, 2016). Besides, solar-energy is considered to-be a-*non*-polluting, reliable, and clean-source of energy. In-particular, unlike other-energy-sources (such-as natural-gas, oil, and coal), its-use is *not* accompanied by the-release of any-harmful-gases (e.g., oxides of C/N/S and/or volatile organic-compounds (VOCs)) and particles (e.g., soot, carbon-black, metals, and particulate-matter (PM)) (Jamshidi, *et al.,* 2017; Kharecha & Hansen, 2013; Burt *et al.,* 2013).

The-sunniest-places, of the-planet, are found on the-continent of Africa. As theoretically-estimated, the-potential concentrated-solar-power (CSP), and PV-energy, in-Africa, is around 470 and 660 PetaWatt hours (PWh), respectively (IREA, 2014). Africa has an-exceptional solar-resource (see Figure 4 for Africa's climate, solar-irradiation, and sunshine-duration), which can-be harnessed, for electricity generation, and for thermal-applications. The-desert-regions of North-Africa, and some-parts of Southern- and East-Africa, enjoy particularly-long-sunny-days, with a-high-intensity of solar-irradiation; Sahelian and Tropical conditions also-feature strong-solar-irradiation. Morocco, a-northern-African-country, for-example, enjoys about 3000hours of sunshine, per-year (Morocco-Country-Report, 2016).

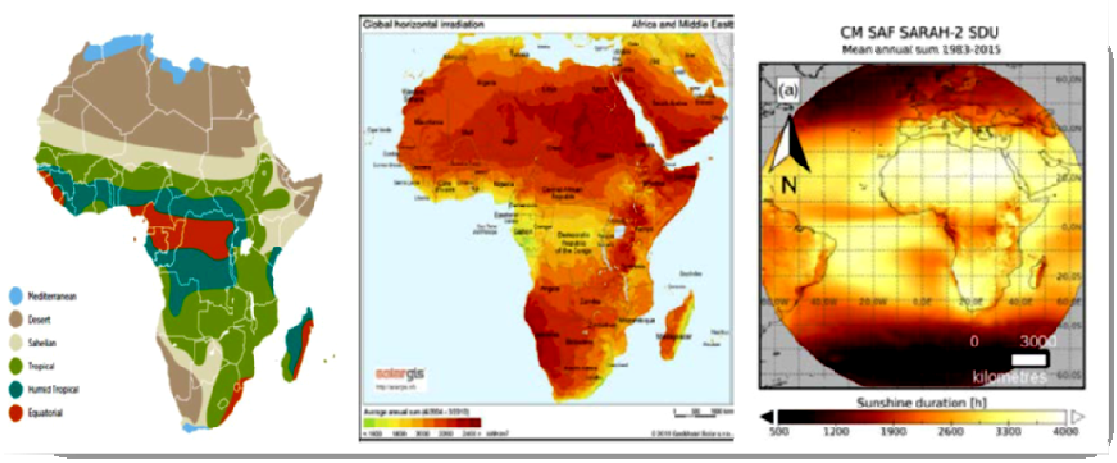

Figure 4: *Extreme-left:* African climate-zones (IRENA, 2015);
Middle: Global-horizontal Solar-irradiation-map, for Africa (GeoSun Africa, 2013); and
Extreme-right: Mean-annual-sum (hours) of SDU (Sunshine-duration), 1983-2015 (Kothe *et al.,* 2017).

Due-to the-geographical-location, of sub-Saharan-Africa, its-contribution to-global-supply of energy, using solar, could-be significant, if adequate-infrastructure is available (Renewables, 2015). Solar-energy is versatile; it can-be-utilized, at-various-scales, from the-small/household and community levels, to-industrial and national-scale-operations. On a-small-scale/the-household-level, solar is used-for lighting, cooking, water-heaters and solar-architecture- houses; medium-scale-appliances include water-heating, in-hotels, and irrigation. At the-community-level, solar-energy is used for vaccine refrigeration, water-pumping, purification, and rural-electrification. On the-industrial-scale, solar-energy is used for pre-heating-boiler-water, for industrial-use and power-generation, detoxification, municipal-water heating, telecommunications, and, more-recently, transportation (solar-cars) (Ecosystems, 2002). Despite the-fact, that most-parts of Africa, receive in-excess of 2000 kWh, of global-solar-irradiation, annually, the-continent has *not* seen *substantial*-development in-solar-energy power-plants (Quansah *et al.,* 2016).

Direct-solar-energy can-be broadly-categorized-into (Energy-sector in-Africa, 2007; Karekezi & Ranja, 1997): (i) solar-photovoltaic (PV) technologies (converting the-sun's energy into electrical-energy); and (ii) solar-thermal-technologies (using the-sun's-energy, directly for heating, cooking, and drying, etc.). The-second-category is particularly-important, as according to NER (2001), one of the-largest-consumers of domestic-electricity is water-heating, typically-accounting for about 30 to 40% of electricity-bills.

On-the-other-hand, grid-connected-systems typically-comprise solar-modules and grid-type inverters; the-grid serves as the-storage-facility, thus avoiding the-cost of batteries, and hence reducing the-cost of the-system. They are usually-installed, utilizing rooftop-spaces, and are designed to-feed into-the-distribution-utility-grid (with configurations that allow self-consumption). In-this-arrangement, when the-PV produces more-electricity, than-needed, the-surplus-electricity is fed, into-the-grid, while electricity is taken, from-the-grid, when it produces less-electricity, than-needed. The-estimated two-thirds, without electricity, in-Africa, can *only* currently-utilize PV in *off*-grid-mode (Quansah *et al.,* 2016).

Besides, there is growing-evidence, that solar-PV-projects, in the-region, have mainly-benefited high-income-segments of the-population, due-to the-high-cost of solar-PV. Solar-PV is unaffordable, to-majority of the-population, in-sub-Saharan-Africa, given the-high-levels of poverty (Karekezi & Kithyoma, 2002). In-Kenya, for-example, the-cost of energy, from solar-home-systems, was reported as-between USD1.0 and USD 7.6/kWh, depending on the-battery-type, used. The-fact, those-systems must always-come-with a-battery-storage, significantly-increases the-cost. Most-African-rural-dwellers, living on-less-than USD 2, per-day, can*not* afford these-systems, without financial-assistance (Baurzhan & Jenkins, 2016; Ngetha *et al.,* 2015). The-cost of solar-PV, however, continues to-drop, and in-2014/2015, tenders in-Brazil, Dubai, and Panama, yielded electricity-prices as-low-as USD 0.06/kWh-USD 0.087/kWh (IEA, 2014). Although solar-power-systems require an-upfront-investment, for their-installation, they otherwise operate at very-low-costs (Kabira *et al.,* 2017); for-example, it takes about USD 2.0, per-month, to-run a-solar-lighting-systems, in-comparison to a-kerosene-lighting-systems at USD 4.0-15.0, per-month (IFC/WB, 2012).

In-addition-to high-initial-installation-cost; relatively-low-efficiencies (10-20%) of most-domestic solar-panels; short-battery-lifetimes; safe-disposal-concern of spent-batteries; large-storage-space requirement for

batteries which are, often, large and heavy; insufficient-facilities exist for recycling of spent-panels (to-recover precious-metals, such-as silver, tellurium, or indium); and another-obvious shortcoming is that solar-energy can *only* be harnessed, during the-day, and works most-efficiently, when it-is-sunny (Energysage).

The-above-account shows the-great-potential, of solar-energy, in-Africa, alongside-with its-current limitations. In-order-to-benefit from the-potential, the-limitations have to be-addressed, therefore, much research is required (on-the-indicated-areas), as-well-as political-will (to-prioritize proper-MW), and large-capital-investments, among-others.

4.4.2. Analysis of Dumping of Hazardous/toxic-wastes

At-the-Council of Ministers, African-countries had declared the-dumping of dangerous-substances, toxic, and hazardous-waste, in-Africa, as 'crimes against Africa and African people'. The-study also-showed, that such-damping is *not* limited to-the-African-continent. Besides, such-wastes, if handled/disposed improperly, can bring potential-severe-risks to both; human-health and the-environment, due to inherent hazardousness/toxicity of such-wastes, among other-factors.

UNESCO-EOLSS stated, that due-to superior-information-availability, and hence, broad-public awareness of harmful-effects of hazardous/toxic/radioactive-waste, most-citizens, of industrial nations, had-already-developed a '*NIMBY'* ('not-in-my-backyard') attitude, toward the-disposal of such-wastes, in their-localities. This-attitude, in-conjunction-with a-tightening of environmental-rules and standards, and escalating-disposal-costs, makes it very-difficult, if *not* impossible, to-site new-WM-projects, and even maintain the-existing-ones. For-example, in-the member-states, of the-European-Economic-Area (OECD), 26,169 landfills are registered; out of which *only* 325 are for the-hazardous-waste. In-addition, in six EU-countries (Austria, Greece, Ireland, Iceland, Liechtenstein, and Luxembourg), there are *no* landfills for hazardous-waste. Besides, *only* 152 of 1,258 registered waste-incineration-facilities are provided, for the-treatment, of hazardous-waste (EEA, 2009). The-facts that, there is a-limited-number of hazardous waste-treatment-facilities, in-OECD, and in-the-world, in-conjunction with-increased-awareness of population of potential-dangers of wastes and waste-management-facilities, *only* intensified the-tendency of illegal-disposal/trade/dumping of waste, largely to-the-developing-world. The-path of least-resistance, and in-addition, low-labor-cost, low-operating-costs, having different-manufacturing-quality-standards, *not* so-strict-environmental-regulations, and the-discrepancy in-the-cost (up to 400%) of waste-treatment (O'Neil, 1998), provides a-powerful-incentives for the-export of such-wastes to-developing-countries. This can be-done, illegally, for bare-dumping, or possibly, legally, for recycling (as a-trade), *but* without proper-controls on public and occupational-health and environmental-pollution. On-the-other-hand, widespread-trade, in-materials, recovered from-waste, can-be attributed to the-fact, that these-recovered materials, are *no* longer considered as-waste, *but* as-products, and hence, they can-be-traded, freely, without the-need, for waste-handlers, to-obtain WM-licenses.

The-study also-revealed, that the-majority of waste-handlers, is children, who open to-the-elements of direct and indirect-exposure. Child-workers, dealing with such-wastes, are exposed to a-variety of hazards, e.g., falling-objects, chemicals, abusive-employers, along with many-other social-problems, related to-human-survival, in-such a-harsh-environment. Injuries and heavy-metal exposure constitute two of the-greatest-threats for-child-workers (IPEC, 2011). Besides, they often-live in poor-sanitary-conditions, and suffer stigmatization, harassment, and exploitation (Van Eerd, 1996). Children's special-vulnerability and increased-susceptibility to-adverse-health-outcomes can-be-further exacerbated by many-factors, such-as malnutrition (Suk *et al.,* 2003), and will likely require a comprehensive, preventive-approach to-protection from e-waste-harm. In-addition, education on-potential health-effects will-be needed, for workers, including children, as-well-as people, who live near, previous, or current-recycling-sites (Heacock *et al.,* 2015).

4.4.3. Analysis of e-waste-dumping

This-study exposed that there is *no* single-universal-definition of e-waste. According to Lundgren (2012), the-lack of a-precise-definition of e-waste is one of the-key-issues, which need to-be-addressed, on an-international-level.

The-e-waste-*flow* is also-being-shown to-be multi-dimensional, and multi-directional (not *only* from developed to developing-countries). For-instance, while e-waste, is *not* exclusively-generated by wealthy-countries, such-countries do contribute-substantially to-e-waste-problems, in-low to-middle income-countries, due-to regulatory-ambiguities, which allow EEE-export, for re-use, regardless of actual-product-functionality. Sending old-electronic-equipment, to-developing-countries, is often disguised as supposedly 'bridging the-digital-divide', in-reality, however, it-is simply throwing-away, of largely useless-equipment, on the-poor, and creating a-'digital-dump' environmental-hazard; NIMBY-attitude at its-best. NIMBY-attitude, however, did *not* work, in-the-example of Italian-eco-mafia, which, in-order just-to-save-money, on hazardous-waste-transportation, decided to-dump the-waste, in their-own-backyard, manifesting a 'profit-at-*any*-cost' mind-set.

Besides, many-developing-nations either; lack adequate-regulations, applying to this-relatively new-waste-stream, or lack effective-enforcement of new-e-waste-regulations (BAN, 2011). In-this-regard, at the-European-Union-context, there are some-additional-measures to-regulate e-waste, such-as: The-Aarhus-Convention; The-

Waste-Electrical and Electronic-Equipment (WEEE) Directive; The-RoHS Directive; REACH; and The EU-Waste-Framework-Directive. At a-regional-level, the-Libreville Declaration on Health and Environment, in-Africa, recognizes that there is a-need for further-research and policies, to-increase understanding of the-vulnerability of humans to environmental risk-factors, particularly in-Africa. Risk-factors, identified, in-relation to e-waste, are: chemicals, poor-WM-practices, and new-toxic-substances (WHO Regional-Office for Africa, 2009). The-2008 Durban-Declaration on e-Waste-Management, in-Africa, followed the-2006 Nairobi-ministerial declaration on e-waste, developed from COP8 of the-Basel-Convention, requires countries to-follow their-own process to-define their-responses and formulate actions in-relation to the-e-waste-problem (Marriott, 2011).

Globalization of e-waste has-adverse-environmental and health-implications, as developing- countries face economic-challenges and lack the-infrastructure, for sound-hazardous-WM, including recycling, or effective-regulatory-frameworks, for hazardous-WM (SAICM, 2009). Emerging e-waste-stream has also-brought-about its-own-challenges and potentials; challenges should-be-addressed, in-order-to-exploit the-potentials.

Among the-potentials, is the-booming-demand for rare-earth-minerals, used in the-manufacture of electronics, which could boost e-waste-recycling, in-the-future. The-cost of recycling is also-declining in-developed-countries. While the-e-waste-stream is *only* a-small-portion (5%), of global-municipal-waste, it also-plays a-significant-employment-role, in the-recycling-sectors, of some-low and middle-income-countries (Modak, 2011). Besides, in-2009, UNEP analyzed 11 countries, for their sustainable e-waste-recycling-potential. Kenya, Uganda, Senegal, and Peru were identified as-promising, in-terms of the-introduction of pre-processing-technologies, with a-focus on capacity-building. India and China have potential for the-introduction of pre- and end-processing technologies, with strong-support, in-capacity-building, in-the-informal-sector. South-Africa, Morocco, Colombia, Mexico, and Brazil, have-potential to-adapt pre- and end-processing-technologies, to their-own needs, following a-technology and knowledge-exchange. There are other-opportunities, such-as in green-design, innovation, life-cycle-analysis, public-outreach, social-policy, and so-on (UNEP, 2009b).

The-challenges, identified, in e-WM, are numerous, from illegal-dumping, lack of national-specific-e-waste-legislations; to health-hazards, related to its-improper-management. In-addition, on-one-side, recycling, for-example, of metals, contained in-electronic-goods, may reduce the-need for mining virgin-materials. On-the-other-side, it-is estimated, that *only* 25% of valuable-metals are recovered, during *informal*-e-waste-recycling (UNEP, 2008). Moreover, proper and efficient-recycling, which recovers valuable-materials, with minimal-environmental-harm, is complicated and expensive (European Commission, 2007). Clearly, more-research is needed to-address the-issues of high-cost of proper e-WM, and the-improvement of current-largely-deficient-practices. The-following-text provided selected suggestions/guidelines on how to-approach the-challenges.

The-UNEP-Guidelines on Environmentally-Sound-Testing, Refurbishment, and Repair, of Used-Computing-equipment, provide a-set of principles for donations of *functioning*-used computing equipment. These-principles are (UNEP, 2013b) to: provide a-useful-product; provide an-appropriate product; ensure and verify availability of technical-support, in recipient-community; test, certify, and label, functionality; ensure availably of training, in- recipient-community; ensure full-transparency, contract, notification, and consent, prior to-delivery; and export, in- accordance-with applicable-national and international-controls. Lundgren (2012), also-suggested a-possible-international-solution--a-facility-based shipment, whereby any-company, seeking-to-export e-waste, would-have to-sign a-contract, with a-facility in the-receiving-country. However, for this to-be workable, the-countries, involved, must have national e-waste-legislation, in-place.

In-addition, according to Luther (2010), an-environmentally-sound e-waste-recycling-chain contains the-following-steps: (1) de-manufacturing into sub-assemblies and components; this involves the-manual-disassembly of a-device/component, to-recover-value; (2) de-pollution – removal and separation of certain-materials, to-allow-them to-be-handled-separately, to-minimize-impacts, including batteries, fluorescent-lamps, and cathode-ray-tubes (CRTs). Materials-separation – manually separating and preparing material, for further-processing; (3) mechanical- processing of similar-materials – this involves processing compatible-plastic-resins, metals, or glass, from CRTs, to- generate market-grade-commodities; (4) mechanical-processing of mixed-materials – this involves processing whole-units, followed by a-series of separation-technologies; and (5) metal-refining/smelting – after being sorted, into-components, or into shredded-streams, metals are sent to-refiners or smelters. At this-stage, thermal and chemical-management processes are used, to-extract metals.

If followed as-closely-as-possible, the-above-principles could-drastically-reduce the-amount of end-of-life-computing-equipment, that is mislabeled, and exported as donated 'functional used computing equipment' that is really a-waste (UNEP, 2013a). Besides, there are several-suggested-methods, to-help guide, the-improvement and strengthening of e-waste-policy, such-as: Extended-Producer Responsibility (EPR); Life-Cycle-Assessment (LCA); Material-Flow-Analysis (MFA); and Multi-Criteria Analysis (MCA), among-others (Goodwill, 2010).

According to Lundgren (2012), the-future of e-waste-management depends *not* only on the-effectiveness of local-government and the-operators, of recycling-services, *but* also on community participation, together with national, regional, and global-initiatives. Selected-positive developments/ examples, in the-area of e-WM, are: (1) *Legislation*: in-Latin-America, Costa-Rica, is the-first-country, in-the-region, to-develop specific-national e-

waste-legislation (Gavilan-Garcia *et al.,* 2009); (2) *Practices and community-participation*: in-Sweden, an-average of 17 kg of e-waste is collected, per-person, per-year, making the-country the-second-best, in-the-world (after Norway) at collecting e-waste, for recycling (Lundgren, 2012); (3) *Corporal-initiatives:* Dell became the-first major-computer-manufacturer, to-ban the-export of non-working-electronics to-developing-countries, as part of its-global-policy on responsible-electronics-disposal (http://content.dell.com/us/en/corp/d/pressreleases/); (4) *Government Commitments:* Although, the-U.S. A. is one of the-few-countries, which are *not* signatories to the-Basel Convention, and it-is, therefore, absolutely-legal to-export e-waste, from the-U. S. A. to any-country. Nevertheless, in-2010, US-President Barrack Obama commissioned a-Task-Force on Electronics Stewardship, to-create "a national strategy for electronics stewardship, including procedures for how the agencies manage their own e-waste" (ETBC, 2011); (5) *Innovative MW-approaches*: Pilot-projects in-China and India, on "Best-of-2-Worlds " approach, indicated its-successful-implementation, with environmental, safety, and economic-benefits (Wang *et al.,* 2012); and (6) *Growth of formal-recycling in developing-world*: In-Guiyu, China, possibly the-largest-e-waste-recycling-location, in-the-world, about 100,000 people is employed, as e-waste-recyclers (Heacock *et al.,* 2015).

Electrical and electronic-wastes (e-waste) are rapidly-growing-forms of waste, which are also-generating public-health-concerns. E-waste contains many-valuable-materials, which have an-economic-value, when recycled. Unfortunately, the-majority of e-waste is recycled in the-unregulated informal-sector, and results in-significant-risk for toxic-exposures to the-recyclers, who are, frequently, women and children (Perkins *et al.,* 2014). Needless to-say, that child-labor should-be abolished, where still-practiced, and waste-exposures of pregnant-women should-be eliminated/reduced, to-mitigate harmful health-effects.

Another-challenge is that little is known, about the-toxicity and environmental-properties, of over 1,000 of the-chemicals, identified in-the-e-waste-streams (Lundgren, 2012). Moreover, the *'cocktail-effect'* of the-interaction of chemicals, can-be greater, than the-effect of the-chemicals, individually. In-addition, even if individual-components, in a-mixture, do *not* each, separately, have harmful-effects, the-mixture, itself, may produce harmful-effects (Kemi, 2011). Besides, a-major-gap remains in-understanding the-potential-impact of mixed-chemical-exposures, and how they may-interact with *non*-work-exposure, such-as cigarette-smoking (ILO, 2010). More-research, on-the-indicated-issues, should-be, therefore, undertaken.

Additionally, the-'Solving the E-waste Problem (StEP) Initiative', a-coordinated-global-effort, brings expertise to-meet the-social, political, economic, and environmental-challenges of extracting valuable-resources, from e-waste. It also-facilitates research, analysis, and dialogue, among representatives from: industry, international-organizations, governments, nongovernmental-organizations, and academic institutions (StEP, 2011). A-framework, from the-StEP-Initiative, called the "Best-of-2-Worlds," provides a-philosophy and pragmatic-approach, for e-waste-treatment, in-emerging-economies (Wang *et al.,* 2012). Basically, the-approach retains manual-dismantling of e-waste, in-low and middle-income-countries, with critical-fractions then sent to-high-tech end-processing-facilities, in a-global-market. Pilot-projects in-China and India, indicated successful-implementation of this-approach with environmental, safety, and economic-benefits (Wang *et al.,* 2012). Solving the e-waste-problem may also entail fostering EEE re-designs, to-lengthen product-life-cycles. Besides, improving environmental-conditions, where local concerns and needs, are actively-considered, can-be-achieved, through community-informed engineering-solutions (Heacock *et al.,* 2015).

On-the-other-hand, Ban on *informal*-recycling, is typically-*ineffective*, because the-practice largely-illegal, is easily-relocated. E-waste-recycling is necessary, *but* it should-be-conducted in a-safe and standardized-manner. When possible, e-waste should-be refurbished and reused, as a-complete-product, instead of dismantled (UNEP, 2013a). Lastly, *completely*-eliminating the-presence of toxic-components in-EEE, although attractive, is *not* really-realistic, at-least in-the-near-future. Research in the-area of Cleaner-production, to-substitute toxic-elements to-less-toxic, or even *non*-toxic, would, however, benefit greatly; such-research should-be continuous, systematic, and innovative, e.g. looking at new-engineering materials.

Moreover, the-study illustrated a-great-recycling-potential, particularly with e-waste. The-author believes that Recycling is the-future of human-civilization; however, it *must* be done in the-environmentally sound-manner, to-protect health of workers, and also to-extract maximum/optimum-amount of valuable-materials, from the-waste. Previously, the-function of the-kidneys was-given as an-analogy for waste-management. This-study suggested different-analogy; for-example: a-properly-functioning digestive system extracts *all* the-nutrients, from the-food, and afterwards excretes waste. The-sustainable SWM-system should-be analogous to-a-digestive-system, extracting *all*-the-recyclables from the-waste, and *only* then discarding, the-small-remainder.

Lastly, the-study also-showed that *transnational*-dumping, of different-types of waste, is highly-organized and sophisticated-crimes.

4.4.4. Transnational-Organized-Crimes, including the-concept of 'eco-mafia'.

Organized-crime/mafias has diversified, gone-global, and reached macro-economic-proportions. The-transnational-organized-crime problems include, *trafficking* of: (1) firearms; (2) drugs (heroin, cocaine, etc.); (3) people (smuggling of migrants, and modern-slavery, including for sexual-exploitation); and (4) natural-resources

(including wildlife). In-addition, there is also products-counterfeiting (including pharmaceuticals); maritime-piracy; money-laundering; cyber-crime (including identity-theft, and child-pornography); and organ-trafficking. In-addition, UNODC (2010), stated, that classically, there are two-major-subheadings, under which *environmental-resources*-offences fall. One is crimes, related-to pollution, in-particular hazardous-waste-dumping, and the-trade in ozone-depleting-substances. The-second is crimes, related to-illicit-harvesting of natural-resources, in-particular: threatened-animal species, timber, and fish. It-is worth to-mention, however, that UN, in-2010, did *not* even mentioned *eco-mafia*, in-their-final-report on investigation "Transnational Organized Crime Threat Assessment". In-this-regard, further-elaborations is in-order.

The-term/label '*eco-mafia*' was first-used, by the-Italian-environmental-group *Legambiente*, in-1994, and is now widely-accepted in-Italian-society to-mean 'organized criminal networks that profit from illegally disposing of commercial, industrial and radioactive waste' (South, 2010). This-term also-has-entered in the-common-global-language to-indicate a-sector of the-mafias, involved in-illicit- activities, posing *serious*-risk for the-environment.

'*Eco-mafia*' was also named, 'rubbish-tzars' (Ruggerio & South, 2010), conducting 'Environmental-related-crime' (Banks *et al,* 2008); 'dirty-collar-crime' (Walters, 2012); or operating in "dirty-economy' (Obradovi *et al.,* 2014). Eco-mafias' interest, however, is *not* limited to only illegal-waste-dumping. According to Hayman & Brack (2002), the-following five-key-areas, were adopted, internationally, when referring-to trans-national and organized-environmental-crime: (i) illegal-trade in-endangered-species and wildlife (breach of the-1973 Washington-Convention on International-Trade in Endangered-Species (CITES)); (ii) Illegal-trade in ozone-depleting-substances (breach of the-1987 Montreal-Protocol on Substances that Deplete the-Ozone-Layer); (iii) Illegal-dumping, trade, and transport of waste and hazardous-substances (breach of the-1989 Basel Convention on the-Control of Trans boundary-Movement of Hazardous-Wastes and Other-Wastes and their-Disposal); (iv) Illegal, unregulated, and unreported-commercial-fishing; and (v) illegal-logging and trade, in-protected-woodlands. In-this study 'illegal' does *not* only refer to the-dumping, of the-waste, *but* also to its-transportation, or management of landfills, in-violation of international or domestic-legal-provisions (ESC, 2012).

Low-risk of prosecution, light-sentences, and the-guarantee of high-profits, waste-management and illegal-waste-trafficking have-become an-attractive-business for criminal-networks. Apparently, eco-mafia is a-big-business, and is currently one of the-most-profitable-forms of criminal-activity (Banks *et al,* 2008). The-Europol (OCTA, 2011); Clarke (2011); and UNEP (2005), estimate that organized-crime syndicates earn, globally, between USD 20-30 billion, per-annum, from environmental-crimes; In-Italy, alone, 'eco-mafia' profits are estimated at 20.8 billion Euros, in-2008 (Legambiete, 2009).

It-is also-widely-recognized, that organized-environmental-crime-syndicates, motivated by-substantial-financial-rewards, continue to-flourish and expand, in-disadvantaged-societies, with porous-borders, where corruption is widespread and regulation poor (UNODC, 2009). According to Terekhova (2011), due-to massive and widespread-corruption, throughout the-chain of waste-handling, 'eco-mafia' increasingly-cooperates with many-stakeholders, including public-officials, in-charge of permits, law-enforcement, port-authorities, and customs (during export/import-clearance), as-well-as politicians, who can ease the-solving of bureaucratic-issues, related to the-issuing of permits, and document-falsification. Such-activities commonly conducted *via* brokers and facilitators.

Besides, organized-environmental-crime is identified by the-UN, as a-key-factor in the-impoverishment, displacement, and violent-conflicts of millions of people, notably in developing societies (UNODC, 2009). This-crime poses *not* only a-serious-threat to the-environment and human-health, *but* has also-become one of the-causes for social and economic-instability (ILO, 2012). As recently highlighted, by the-UNEP and Interpol, "environmental crime affects all sectors of society and is often linked-with the-exploitation of disadvantaged-communities, human-rights-abuses, violence, conflict, money laundering, corruption, and international-criminal-syndicates" (UNEP, 2013a).

The-Europol also-stated, that illegal-trade, in-hazardous-waste, in the-EU, is a-sophisticated network of criminals, with a-clear-division of roles (e. g., collection, transportation, disposal, or legal-aid), which increasingly-collaborates with companies/producers of hazardous-waste (who simply need to-dispose-off their-waste, at the-least-cost-possible, and do *not* want to-carry any-responsibility, for the-consequences of improper-waste-handling and disposal). For-example, the-2006 toxic-waste dumping-incident, in-Ivory-Coast, was perfect-illustration an-international-organized-crime, confirmed by the-following-facts: the-owner of the-ship was a-Greek-company, the-ship was registered in-Panama, the-lessee was a-Swiss-Dutch-company, based in-Great-Britain, and the-operator was Russian-crew (Monzini, 2006).

Legambiente (2011) reported, on investigations of the-Italian-Parliamentary-Commission, in-1997, which revealed, that different-types of waste, had-been illegally-dumped, in-Italy, including toxic-residuals, produced by companies in-Central and Northern-Italy, and even radioactive-sludge, from other-countries. Italian-criminal-groups, involved, in-the-business, the-Camorra, in-particular, opted for dumping the-waste, locally, in-order-to-

minimize transportation-costs. In-addition, a-cooperation, of different-types of mafias, is evident, for-example, weapons-mafia and eco-mafia, in-Somalia. The-civilian-conflict affected Somalia, for over 20 years, the-absence of the-rule of law, and respect for human-rights, encouraged Italian-mafia groups and corrupted-public-officials, to-enter the-country. In-2006, the-Italian Parliamentary-Commission investigated on the-possible-link, between waste and arms-trafficking. Evidence was-found, that conventional-weapons were-given to-armed-groups, involved in the-civil-conflict, in-return for sites, where hazardous-waste, of all-kind, was buried, dispersed, or even burnt. Still today, Somali-people are suffering, from the-consequences of this-illicit-waste-trafficking, from toxic and radioactive-waste; cancer in-adults, childhood-leukemia, and severe-deformations to the-urinary-system (Legambiente, 2011; Terekhova, 2011). Moreover, in-December 2006, the-European-Parliament identified that 60 environmental-infringement notices remained-outstanding, against the-Italian-Government (the-highest in-Europe), mainly for breaches of waste-management (Walters, 2012). According-to Professor-Walters, in-the-Italian-regions of Campania, Calabria, Sicily, and Peglia, 31 million-tons of domestic and commercial-waste simply 'disappeared' in-2008; dumped at-sea, or in-local-waterways (Walters, 2012). Eco-mafia, however, is *not* limited-to Italy, alone; it-is indeed a-global/transnational-crime (ESC, 2012; Walters, 2012; Interpol, 2011; Elliot, 2009; and Hayman & Brack, 2002).

To-control/fight eco-mafia/'crimes of the-powerful', area of 'green-criminology' emerged, and is rapidly-expanding (South & Bierne 2006; Lynch & Stretesky, 2003; South, 1998). The-role of green-criminologists is to-unpack and disentangle the-ways that policies and practices of legitimate-trade facilitate the-opportunities and activities of organized-transnational environmental-criminal-networks (Walters, 2012). Besides, to-understand the-complexities of organized-environmental-crime require an-examination of the-networks of corruption, which facilitate criminal-markets (see Elliot, 2009 for more-details). In-this-regard, UNICRI is taking part in-the-'Countering WEEE Illegal-Trade-project (CWIT)', led by the-Interpol. This two-year-*research*-project aims to-analyze the-illegal-flows of e-waste, highlighting connections with other-criminal-activities, and identifying the criminal networks involved.

Lastly, activities of eco-mafia, are largely, illegitimate, increasingly pose a-threat for the-global-socio-economic-stability. It-is, therefore, imperative to-raise-awareness of the-international community, enforcement-agencies, environmental-organizations, and civil-society, on such-practices/ serious-crimes, and the-dangers posed to-health and environment, alongside with the-negative-impact on the-legal-economy. Furthermore, more-research is needed, on the-criminal-networks, behind the-illegal-waste-trafficking.

The-next-two-sections will elaborate-on illegal-waste-trafficking as Environmental-Racism, and also as a-violation of human-rights.

4.5. Environmental racism.

EPA-US defines Environmental-Justice as: "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, culture, education, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies". Fair-Treatment means, that no group of people, including racial, ethnic, or socioeconomic-groups, should bear a-disproportionate share of the-negative- consequences, resulting from industrial, municipal, and commercial-operations, or the-execution of federal, state, local, and tribal-environmental-programs and policies (Bryant, 2006; Frohlich, 2003; Luke *et al.,* 2001). The-export of hazardous-waste, for disposal, in developing-countries, represents a-massive-failure of environmental-justice, on a-global-scale, as it places a-disproportionate burden, on poor-countries, and threatens human-health and the-environment (Lipman, 2000).

On-the-other-hand, Environmental-racism is a-term, used to-describe environmental-injustice, within a-racialized-context. In-some-Western-nations, environmental-racism refers-to socially-marginalized racial-minority communities, which are subjected to disproportionate-exposure of pollutants, the-denial of access to-sources of ecological-benefits (such-as clean-air, water, and natural-resources), or both. Within an-international-context, environmental-marginalization may apply to disadvantaged-ecological relationships between industrialized-nations and the-Global-South, and is often-associated with colonialism, neo-liberalism, and globalization (Melosi, 1995). African-American civil-rights-leader, stated that "environmental racism is racial discrimination in environmental policy-making and enforcement of regulations and laws, the deliberate targeting of communities of color for toxic waste facilities, the official sanctioning of the presence of life threatening poisons and pollutants for communities of color, and the history of excluding people of color from leadership of the environmental movement" (Chavis *et al.,* 1987). Historically, the-term is tied to the-environmental-justice social-movement, which began in the-1970s and 1980s, in- the-United-States. Racism and environmental-justice unified, for the-first-time, during the-1983 citizen-opposition to a-proposed PCB-landfill in-Warren-County, North-Carolina (Mohai *et al.,* 2009). The-term 'environmental-racism' came-into-use at a-conference, held at the-University of Michigan's School of Natural-Resources, in-1990 (Bullard, 2011).

The (native) Indian-Removal-Act, of 1830, and the-Trail of Tears, may-be considered as early-examples of environmental-racism, in the-United-States, while nuclear-waste-dumps on Native American-reservations;

Chester, Pennsylvania; New-Orleans, Louisiana; and Louisiana's Chemical Corridor/Cancer-Alley, are the-modern-day-examples. Besides, the-area of Altgeld-Gardens, Chicago, Illinois, became known as a 'toxic doughnut', with 90% of its-population African-American, and 65% below the-poverty-level. The-Altgeld-Gardens is considered a-classic-example of environmental-racism. The-known-toxins and pollutants, affecting the-Altgeld-Gardens-area include: mercury, ammonia-gas, lead, dichloro-diphenyltrichloroethane (DDT), polychlorinated-biphenyls (PCBs), polycyclic-aromatic hydrocarbons (PAHs), heavy-metals, and xylene (see Bullard et al, 2007; Lerner, 2005; Checker, 2005; Bullard, 2004; Holifield, 2001; Pulido, 2000; and Godsil, 1991).

For-example, according to Bunyan & Mohai (1992), people of color, face worse-health-burdens (asthma, cancer, birth-defects), because of environmental-pollution, and have less-access to-health-care, information, means of participation, and economic and political-influence, in the-processes of environmental-decisions, laws, and policies.

In-1987, the-groundbreaking-report on Toxic Wastes and Race in the United States, by Chavis *et al.* (1987), found race to-be the-most potent-variable, in-predicting where commercial-hazardous waste facilities were located, in the-U.S.A., more-powerful than household-income, the-value of homes, and the-estimated-amount of hazardous-waste, generated by industry. Twenty years later, in-fact, in Toxic Wastes and Race at Twenty report, that "people of color are found to be more concentrated around hazardous waste facilities than previously shown" (Bullard *et al.,* 2007). In-particular, more-than 9 million people (9,222,000) are estimated, to-live within 3 kilometers of the-nation's 413 commercial-hazardous waste-facilities. More-than 5.1 million-people of color, including 2.5 million Hispanics or Latinos, 1.8 million African Americans, 616,000 Asians/Pacific Islanders, and 62,000 Native-Americans (red-Indians) live in-neighborhoods, with one or more-commercial-hazardous-waste-facilities. According to Bullard et al. (2007), for many WM-industries (such-as: landfills, incinerators, chemical-plants, refineries, and other-polluting-facilities) it-is a 'race to the bottom', where land, labor, and lives, are cheap; so-called, environmental 'sacrifice-zones', where vulnerable-communities, and individuals, often-fall, between the-regulatory-cracks. He also-added, that such-communities, are, in-many-ways, 'invisible'-communities, including people of color, immigrants of all-races, illegal-settles, and low-income-communities. Likewise, another-study, conducted in-between the-above-two, found, that people of color, are 47% more-likely to-live near a-hazardous-waste-facility, than white-Americans (Goldman & Fitton, 1994). The-landmark-study also spawned a-series of academic-books, including Dumping in Dixie:Race, Class, and Environmental Quality in 1990 (Bullard, 2000). Since then, several-studies, in-the-U.S.A., have also-identified a-correlation, between race, socio-economic-status, and the-location of hazardous-waste-facilities (EEA-ETC/RMW, 2008). Besides, Pace (2005) also-cited an-EPA-research project, showing that African-Americans are 79% more-likely, than whites, to-live in-neighborhoods, where industrial-pollution is suspected of posing the-greatest-health-danger. In-addition, most-recent comprehensive-study of particulate-emissions, across the-United-States, published in-2018, found that African-Americans were exposed to 54% more-particulate-matter-emissions (soot), than the-average American (Mikati *et al.,* 2018).

Environmental-racism also-exists on an-international-scale. In-one alleged-instance, the French aircraft carrier Clemenceau was prohibited from entering Alang, an Indian ship-breaking yard, due to a lack of clear documentation about its toxic contents. French President Jacques Chirac ultimately ordered the carrier, which contained tons of hazardous materials including asbestos and PCBs, to return to France. Add details from PPT. In-yet-another-examples, of alleged-environmental-racism, both, in-1984, the-Union Carbide chemical-plant, in-Bhopal, India, and the-PEMEX liquid-propane-gas-plant, in-Mexico-City, blew-up, killing thousands, and injuring roughly-a-million, nearby-residents. The-horrific-images, of the-victims, in-India, and Mexico, spread-out an-interest, in-environmental-racism, around-the-globe, as both-plants were-foreign-owned, refused to-be set-up, in-their-countries (Westra & Lawson, 2001).

In-Europe, environmental-racism, has-been-documented, in-relation-to-racialized-immigrant and migrant-populations, alongside Romani (Roma/Gypsy), Yenish, Irish-Traveller, and communities (such-as: the-Sami, Komi, and Nenets) from within continental-borders. In-particular, the-transition, from socialism, in-Eastern and Central-Europe, has led to an-increased-visibility of Romani-marginalization and environmental-exclusion, whose effects continue to-be felt, throughout-Europe. Such-incidences were well-publicized, in-Central and Eastern-Europe, including: Bulgaria, Lithuania, Poland, Czech Republic, Slovakia, Hungary, Ukraine, Romania, Bulgaria, Slovenia, Croatia, Bosnia and Herzegovina, Serbia, and Albania (see UNECE (2013); Byrne (2013); Vincze (2013); Filčák (2012); Gökçen (2012); Orta (2010); Babourkova (2010); Mikulska & Hall (2009); Harper *et al.* (2009); and Pellow (2007)). In-particular, in-Veles, Macedonia, 700 Romani-families, in the-town, were exposed, annually, to 62,000 tons of zinc, 47,300 tons of lead, and 120,000 tons of sulphur-dioxide, from a-nearby smelting-plant. Despite opposition, from experts advising the-project, the-smelter was built 300 meters from the-houses of 60,000 people (Spiric, 2015). Moreover, the-UNHCR have relocated, 500 displaced-Romani, from Mitrovica, to a-camp in-northern-Kosovo, located on top of an-abandoned lead-tailings-site, at the-former Trepča-mining complex, in-Kosovska. In-2005, the-WHO stated that "the worst environmental disaster for

children in the whole of Europe" was happening, declaring the- camps unfit, for human-habitation, and in-need of immediate-evacuation (Polansky, 2005). Besides, the-settlements in-Wrocław, Poland, for Romanian Romani-origin had no heated-homes, running-water, electricity, or sewerage, and were-constructed, using materials, salvaged from dumps. Residents at the-settlement were employed in scrap-metal-collection. At the-former Kamieńskiego-Street-shantytown, there was documentation of waste-disposal-concerns, raw-sewage-dumping, and burning of plastic, causing pollution (Jupowiecka, 2016).

The-incidents of environmental-racism were also-documented in-Western-Europe, including: Germany, United- Kingdom, Ireland, France, Portugal, Spain, Italy, Greece, Sweden, and Turkey (see Laurian (2017); Sievert & Jackson (2016); Illuzzi (2014); Pietarinen ed. (2011); Miltos & Kalliopi (2009); Staniewicz (2009); Ovalle & Peric (2009); ERRC (2004); Power (2004); Open Society Institute (2002); and Helleiner (2000)). For-example, 'travelers' in-Ireland, have a-documented-history of experiencing racism, within an-environmental-context, particularly, with-regards-to hazardous-working-conditions, in the-metal-recycling-sector. According-to-the-resent-research, by ISSDA (2010), approximately 2,700 Irish-Travellers lacked access to-running-water, out of a-total Traveller-population of 36,224, in the-Republic of Ireland, and 3,905, in-Northern-Ireland. In-the-same-survey, nearly 25% of Traveller respondents stated, that they felt either 'unhealthy, or very-unhealthy' in their-places of residence.

The-Russian-Federation (Euro-Asia) is not an-exception; for-example, in-2005, Romani-settlements, in-Arkhangelsk and Kaliningrad, became the-target of xenophobic-political-campaigns, in which local-politicians used elections-platforms that argued for "'cleaning' their-city of 'gypsies' as one of their-major promises, to-be-fulfilled, after winning the-elections. In-addition, to-geographic marginalization, due to-xenophobia, of Romani, in-Russia, the-dispossession of indigenous-people, from their-lands, throughout-Russia, for natural-resource-extraction, has a-long historical-context of racism. According-to indigenous-studies-scholar, Aileen Espiritu, on Aboriginal-Nations/Natives in-Northwest-Siberia: "As non-European peoples, the Khanty, Mansi and Yamalo-Nenets were seen as-inferior-races, by the-Russians, and were, therefore, exploited for their-goods and resources. Forcible-Tsarist- jurisdiction over Khanty, Mansi and Yamalo-Nenets-territory began in the-sixteenth-century". For-more-details, see IWGIA (2016); Stallard (2014); IWGIA (2014); Haugland (2013); Kenyon (2013); Digges (2013); Bernard *et al,* eds. (2008); and Madslien (2006).

4.6. Illegal-waste-trafficking as violation of Human-rights

Human-rights, defined by Gwam (2000), and adopted by this-study, as:

> The fundamental, inherent and inalienable civil and political, as well as economic, social and cultural rights of the human person to personal freedom, life, justice, good health, food, etc., which must be protected and promoted, and should never be infringed, by the government or state; and it is the concern of the international community, in order to live happily as a united family, to ensure that the human person, no matter his/her race, sex, language or religion enjoys and realizes these rights.

The-Universal-Declaration of Human-Rights (UDHR) is a-historic-document, that was adopted by the-United-Nations General-Assembly, at its-third-session, on 10th December, 1948, as-Resolution-217, at the-Palais de Chaillot, in-Paris, France. The-Declaration consists of 30 articles, affirming an-individual's rights which, although *not* legally-binding, in-themselves, have-been-elaborated in-subsequent-international treaties, economic-transfers, regional-human-rights-instruments, national-constitutions, and other-laws (Brown, 2016; Steiner & Alston, 2000). Relevant to-this-paper, the-Article 1, of UDHR, states that "all-human-beings are born free and equal in dignity and rights"; the-Article 2 indicates, that "Everyone is entitled to all the rights and freedoms set forth in this Declaration, without distinction…"; and the-Article 3 reads, that: "Everyone has the right to life, liberty and security of person".

Human-rights-abuses, however, did *not* stop, when the-Universal-Declaration on Human-rights was adopted, in-1948. It was at the-World-Conference on Human-Rights, in-Vienna, June 1993, that illicit-dumping of toxic-wastes was recognized, by consensus, for the-first-time, as a-human-rights-issue (Gwam, 2011).

In-this-paper, human-rights were looked-upon, from the-*generation*-approach. In-particular, *first-generation*-rights, libertarian in-nature, relate to-the-sanctity of the-individual and their-rights, within a-state, are usually-regarded as-those-rights, expressed in the-International-Covenant on Civil and Political- Rights (ICCPR). These include (Flintermann, 1990; Vasak, 1979): the-right to-life; the-right to-administration of justice; the-right of the-child; and the-right to-vote and be-voted for. The *second generation* rights, are the-realizable-rights, are those-rights, incorporated in the-International Covenant on Economic, Social and Cultural-Rights (ICESCR). These include: the-right-to-good-health; and the-right-to-education. The *third-generation* rights, include 'solidarity-rights' or 'collective-rights'

According-to Fidler (1999), toxic-waste-dumping-issue cuts-across civil, political, economic, social, and cultural-rights; for-example, toxic-waste-dumping and its-adverse-effects, on the-right to-health, will-have implications on the-right to: life, liberty and security of persons, privacy, adequate-standard of living, food, housing, education, development, and other-rights. Besides, the-UN, stated, that human security includes 7-

main-categories, such-as: political, economic, food, health, environmental, personal, and community (UNDP, 1994). The-overall-goal, of human-security, is to-ensure the-survival, livelihood, and dignity of people, in-response-to current and emerging-threats; indiscriminate-trans boundary-dumping of toxic, hazardous, radioactive, and e-wastes, is definitely, such a-threat.

The-human-rights-dimension is very-broad, as practically-every-measure of risks-control, of waste-dumping, is influenced by some-human-rights. For-example, the-violation of the-Right to-health may decrease/limit human-productivity, and in-turn, may-lead to extreme-poverty and hunger, another human-Rights-violation (food). The-poverty may affect the-education of the-children, a-violation of the-Right of the-child. Extreme-poverty may also-lead to: the-sale of human-internal-organs, child-labor, child-prostitution, and human-trafficking, including for sex-exploitation, among-others, in-order-to generate funds, to-support the-entire-family. This could-be referred-to-as the-Theory of Inter-mix of Rights, which shows, that all-sets of rights, are positively-co-related (Gwam, 2011).

This-study exposed that Ivory-Cost-tragedy is a-clear-violation of the-Right to Life, Good-Health, and Clean and Sound-Environment. The-study also-shows, in-the-following-narrative, that international waste-trafficking, leading to-severe-damages to human-health and to the-environment, can be a-punishable offence. Brief-account of the-Crime and Punishment in the-Ivory-Cost-tragedy: in-the-weeks, following the-environmental-tragedy, the-BBC reported, that 17 people died, 23 were hospitalized, and a-further 40,000 sought medical-treatment (due-to severe-headaches, nose-bleeding, and stomach-pains). These-numbers were revised-upward, over-time (BBC News, 2008). Besides, on 7th September, 2006, the-Voice of America announced, that the 9-month-old-government, of Prime-Minister Konan Banny, resigned, for his-inability to-manage the-toxic-waste-scandal (Bavier, 2009), accepting the-responsibility of the-local-government. The-head of the-Ivorian-contractor, who dumped toxic-waste, was the-*only*-one, who was sentenced to 20 years, in-prison, in-November, 2008. Two-Trafigura-executives, were-also-arrested on 18th September, 2006, *but* released on 13th February 2007, when Trafigura agreed-to-pay, the-Ivorian government, £100 million (USD 198 million), for the-clean-up of the-waste. The-group denied *any*-liability for the-dumping, and as a-part of the-deal, the-government would *not* pursue further-action, against the-group or any-individual, involved. On 20th September, 2009, Trafigura announced, it-would-pay around USD 46 million, to-claimants, noting that 20 independent-experts had-examined the-case, *but* were 'unable to-identify a-link' (Gwam, 2011).

This-study also pointed-out, that widespread, cruel, and systematic/organized-violations of human-rights, due to illegal-waste-dumping, in-Africa (e.g., in-Ivory-Cost, Nigeria, Guinea, Benin, etc.), and in-other-parts of the-world (e.g., India, Mexico, etc), leading to-death and sicknesses, can-be further-adjudicated-upon, in-the-U.S.A., under the-1789 Alien-Tort-Statute, once *all*-local-remedies have-been-exhausted. It-is noted, however, that it might-be-difficult, for developing-countries to-meet the 'exhaustion of local-remedies'-rule, due-to political and economic-power of the-multinational corporations, involved, and the-widespread-corruption, in-judiciary-sector.

4.7. Final thoughts

There is a-common-prejudiced/stereotyped-misconception, that, in-the-developed-countries almost everything (including WM) is: superior, brainy, flawless, highly-organized, and tidy; in-contrast, in-developing-countries, and particularly in-the-'dark'-continent of Africa, almost-everything (including WM) is substandard, mediocre, unsound, ad-hoc, and filthy. The-following-examples will, possibly, demonstrate, that the-situation, at-least, with-regard-to WM, is *not* so 'black and white'.

Selected-examples of challenges, still experiencing by some-*developed*-counties, in-dealing with waste, are summarized, as-follows: **(1)** Angela Giuffrida (2018) reported that, the-city of Rome, has-been-plagued, by problems with its-waste-collection and disposal, since the-Malagrotta-landfill-site was closed, in-2013, in-spite of sending tons of household-waste to-other-Italian-regions and, even, to-Austria. "Italy could be sanctioned by the EU unless authorities in Rome and its wider Lazio region get to grips with a waste disposal crisis that has dragged on for weeks", the-country's environment-minister has warned; **(2)** An-estimated 1.35 million-tons of food and drink, in-Scotland, was wasted, in-2013, according to the-figures, released by Zero Waste Scotland (2016). This is food-waste, where money, time, resources, and effort, are often-wasted, by throwing-away good-food. It-also generates very-harmful greenhouse-gases, contributing to global-warming. This-amount of food, which could-feed approximately 1.2 billion poor/needy people, represents almost a-third of household-waste. In-addition to-this, at least 4.7 million-people, in the-UK, are in-food-poverty; **(3)** The-recent-strike, by garbage-collectors, in-the-Spanish-city of Málaga, which resulted in-enormous-rubbish-heaps, choking the-streets, shows how *not* all-EU-members manage their-waste-well (Reuters, 2016); **(4)** European-Environment-Agency (2016), also-reported that several-countries, in-southern and eastern-Europe, are falling well-below EU-targets, for WM, with Bulgaria, the-Czech-Republic, Poland, Romania, Slovakia, Slovenia, Cyprus, and Greece, among the-worst-offenders, and the-UK also-relies too-much on landfill. Besides, "Many member-states are still land-filling huge-amounts of municipal-waste... despite better-alternatives", the-EU-environment commissioner said; **(5)**

The-Vinca-dumpsite, in-Belgrade, Serbia (Europe) is *still* on the-top-50 list of Biggest *uncontrolled*-Dumpsites. It receives 700,000 tons of waste, annually, including mixed medical-waste and e-waste. The-site is located *only* 2 km, from the-Danube-River, and the-nearest settlements, affecting local-residents and global-environment (Waste-Atlas Partnership, 2014); **(6)** D'Alisa *et al.,* (2010) reported on "Collection crisis--waste piling up in the streets in Naples, Italy", where, according to BBC News (2011), 7200 tons of rubbish is accumulating, every-day, in the-Campania-region. Emergency-solutions, on the-SWM-crises have included new-uncontrolled-dumpsites, near the-city, sparking further-citizen-protests. Such-crises made national and international-headlines in 1994, 1999, 2003, 2008, and 2010. The-area, between Naples and Caserta, has, even, been-nicknamed the "land of fires", as a-consequence of the-frequent blazes, burning-up huge-mountains of illegal and hazardous-wastes. At one-point, in-2007, the US-Embassy, in-Rome, warned Americans, against-travelling to-Naples and its-surrounds, citing health-risks. The city's tourist-trade still-suffers from its-reputation for dirty-streets. Still an-unresolved-issue is what to-do with the 8 million-tons of waste, which accumulated in 'temporary' sites, in the-area, surrounding Naples, as 'this-issue requires money and political-will, both, apparently, are currently lacking'; and **(7)** Overall, on a-per-capita-basis, much-more-food is wasted in the-industrialized world, than in-developing-countries. It is estimated, that the-per-capita food-waste, by consumers, in-Europe and North-America, is 95-115 kg/year, while this-figure in sub-Saharan-Africa and South/Southeast-Asia is only 6-11 kg/year (FAO, 2011).

On-the-other-hand, the-following-narrative illustrates success-stories of some-projects and initiatives, in-SWM, in some-*developing*-counties: **(1)** In-Versalles, Colombia, the-rate of separation at-source, in-2015, was above 80%, with recoverable-materials marketed and organic-matter transformed into-compost, for-sale. Of the 42 tons of waste, generated by the-community, per-month, 27 tons of organic-matter and 7 tons of recycled-materials are recovered and transformed. Overall, the-town has-reduced the-amount of waste by 83%, which would-have otherwise sent to-landfill (GWMO, 2015); **(2)** Waste Electrical and Electronic Equipment (WEEE Centre) is an e-waste-recycling-organization, based in Nairobi, Kenya; it participates in the "Best of 2 Worlds" (Bo2W) model, shipping its-hazardous and non-valuables, through a transparent-flow for end-processing, by international-recyclers and smelters. *Bo2W* is a-concept, developed by the- multi-stakeholder Solving-the-E-waste-Problem (*StEP)-Initiative*, hosted by the UN's research-arm, the-United- Nations-University (UNU). The-recycling-facility receives about 10-15 tons of e-waste (computers, monitors, printers, mobile-phones, batteries and other kinds of e-waste), per-month (GWMO, 2015); **(3)** The-island of Santa-Cruz, Ecuador, has been-implementing separation-at-source, and differentiated-waste-collection, since 2006. The-organic-waste and the-recyclables are sent to their-Recycling-Centre, where the-organic-waste is composted, and the-product is sold, and used by the-municipality, as fertilizer, in municipal-city-green-areas. The-recyclables are manually sorted, compacted and/or shredded, to-be-sent to recycling-companies, on the-mainland. The-residual-waste is sent to-the-sanitary-landfill. In-2012, approximately 50% of the-overall-waste, generated on Santa-Cruz-Island was recycled (Castillo & Hardter, 2014); **(3)** In-the-Republic of Kiribati, the-largest SIDS (small-island developing-state), in-terms-of ocean-territory, a-Beverage container-deposit-system has been-operational, since 2004. Under this system PET bottles and aluminum cans have an AUD 0.05 (5 cent) levy, paid on them, at importation and collected by the Ministry of Finance and Economic Development (MFED). This-cost is passed-on, through the-commercial-system to the-consumer, who upon returning the-empty-beverage-container, at a-collection-point, receives AUD 0.04 (4 cents) back. A-Green-Bag-scheme, for source-segregation and collection, also started in-early 2000 (ADB, 2014); **(4)** In-Mauritius, in-2011, a-private-operator invested in a-composting-plant, where 35,000 tons are processed out of the 450,000 tons of waste, generated-annually(GWMO, 2015); **(5)** The-city of Belo-Horizonte, Brazil, has been a-pioneer in urban-governance on food-security, ever-since 1993. The-City-Food-Bank was established, in-2003, to-contribute to-the-prevention of food-waste, while providing healthy-food, to-those in-need. The-food-waste is collected, from partner-establishments, including: street-vegetable-markets, green-groceries, and supermarkets, and then goes-through a-rigorous process of selection, processing, and storage, with-sanitary-norms strictly-observed. The-processed-food is distributed to-more-than 100 institutions, registered with the-City-Food-Bank, including: day-care centers, homes for the-elderly, orphanages and shelters, benefiting about 15,000 people (Rocha & Lessa, 2009**)**; **(6)** In-2001, the-administration of Quezon-City, Philippines, started work to-transform the-dumpsite into a-controlled- waste-disposal-facility and an-eco-park. In-2004, a-110kW Pilot-Methane-Power-plant was set-up, and in 2007/8 a-Biogas-Emissions-Reduction-Project started. The-project was the-first Clean-Development-Mechanism (CDM)-project, in-SWM, in the-Philippines, and in-Southeast-Asia, and registered under the-Kyoto-Protocol of the-United Nations Framework-Convention on Climate-Change (UNFCCC). GHG-emissions, have-been reduced, by an- estimated 116,000 tons CO_2, per-annum. In-addition, employment has-been-created, and financial-resources, from the-sale of Certified-Emission Reductions, or *carbon-credits*, have-been obtained. The-project is considered a-showcase of best-practices (Payatas: Quezon City); and **(7)** In-1994, the-city of Surat, India suffered an-outbreak of plague-like disease, caused by major-flooding, as a-consequence of uncollected-waste, blocking the-drains (waste-collection was limited to 40%). The-city-administration, have tried many-approaches, over the-years, until SSSM-project,

which over 18 months, *only,* transformed the-city into one of the-cleanest-cities, in the-region. The-initiatives carried-out included: monitoring, infrastructure development, in-slums, engagement of the-private-sector in waste collection and transportation, capacity-building, and coordination, among-municipal-employees, awareness-raising, among the-public, and the-introduction of complaint handling-systems (SSWMP, 2013).

Lastly, it-is in-order-to-mention the-challenges, experienced, during this-study. In-particular, at-some-stages of-the-document-analysis-phase, a-number of statistical-data, were contradicting, drastically. This is in-accord with a-statement of UNIDO (2009), that: "Despite its importance, reliable global MSW information is *not* typically-available. Data is often inconsistent, incomparable, and incomplete". In-addition, specific-data, on waste-generation and characterization, in-African-countries, is, fragmented (*if any*), and, by and large, deficient (Ayuba *et al.,* 2013). In-order-to eliminate/minimize the-contradictions, *only* reliable/reputable-published-sources were-finally-utilized. Besides, it-is worth-to-mention, that ISWA and UNEP are agreed-to-develop, by 2018, globally-recognized and internationally-agreed-methodology and protocols, for collecting waste-data at a-national and city-level. The-newly-available performance indicators, for waste-management, in-cities (for-example the-Waste-aware benchmark-indicators (Wilson *et al.,* 2015), which won both; the 2015 ISWA-Publication-Award, and CIWM's James-Jackson-Award, should-be applied widely, and then updated and further-standardized to-facilitate-benchmarking and monitoring-progress, over-time (WM&R, 2015**)**.

5. Conclusions.

Waste is completely-unavoidable in-any, and every-human-activity; however, the-way the-waste is handled, stored, collected, and disposed-off, will-determine the-future of our-surrounding-environment, to-be-either; clean, pleasant, healthy, and sustainable, or filthy, disgusting, harmful, and wasteful. The-way each individual, family, company, organization, government, and society, at-large, deal with their-waste, will-eventually determine our-own-future, as-humans; the-author believes this-paper provided a 'food for thought' on the-issue.

The-study also warranted that the-waste should-be-treated as a-resource, as it contains many-valuable-materials. The-study offered a-new-analogy; the-*sustainable*-SWM-system should-be analogous to-a-digestive-system, extracting *all*-the-recyclables from the-waste, and *only* then discarding, the-small-remainder/waste. The-author, thus, also-believes that Recycling (with a-capital R) is the-future of human-civilization; however, it *must* be done in the-environmentally-sound-sustainable-manner, to-protect health of workers, and also to-extract the-optimum/maximum-amount of valuable-materials, from the-waste.

The-article also tried to-articulate the-practices and challenges, still experienced by many-countries, in dealing with-waste. The-study also showed, that WM-practices and challenges are *not* really 'black and white'/clear-cut, but rather '100 shades of grey'.

This-review also-justified, that there are, indeed, numerous and different-types of law, at International and regional-level, controlling and regulating SWM, in-both; developed and developing-countries. This-study illustrated, that despite the-existence of International, regional, and multilateral agreements, illegal-trafficking of hazardous, toxic, radioactive, and e-waste, is still-practiced. Such-practices of waste-exporting/trading/dumping for disposal, to-largely, developing-countries, has been-described-as environmental-injustice, or environmental-racism, and it is a-clear-violation of human-rights. Environmental-racism is real, and it-is a-sin, against humanity; logically as any-sin, it should-be exposed, condemned, and fought against, with every-fibre, of impartiality, left in-us.

Finally, this-paper also-does *not* claim to-be *fully* comprehensive, as it-is physically-impossible 'to-fill an-ocean into a-small-cup', and even the-most-comprehensive-review, have to-stop, at a-certain point; nevertheless, the-author strived, indeed, to-provide sufficient, accurate, and balanced coverage on the-subject-matter. Lastly, the-author also-welcomes readers'-feedback, and constructive-criticism (*if any*), *via* drdsmeld@yahoo.com.

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