International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 5 May 2021, pp: 531-547 www.ijaem.net ISSN: 2395-5252

Analysis and Management of E-Waste

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Submitted: 01-05-2021 Revised: 10-05-2021 Accepted: 12-05-2021

ABSTRACT:E-wasteisbecomingoneofthemajorproblems intoday'sworld.Withrapidlyincreasingamountofe-wasteovertheyears,itisnowathreatformankind,therei saneedtofindsomesolutionasquicklyaspossible.Epro ductsafterusearenotdisposedofinanenvironmentlfrie ndlywayinamajorpartoftheworld.Themethodslikela ndfillingandapoorrateofrecyclingofewasteinmostoft hecountrieshaveproducednegativeimpactsonenviro nmentandeconomyaswell.Inthispaper,wehavetriedt ofigureoutthathowmuchewasteproducedinIndiaand world.Wealsostudiedandcomparedthemethodsusedf orewastemanagementinIndiaandsomemajorcountrie saroundtheglobe.Thescenarioindevelopednationsan ddevelopingnationshas beendiscussed.Poormanagementofewasteleadstovar iousimpactsnamelyenvironmental,health,economic allthesearediscussedinthepaperalongwithrelevantca sestudies.Weanalysedsomeoftheinitiativestakenbys omecompaniestoimprovethesituation.Finally, wesummarisedthestepsforenvironmentallysoundma nagement.Aftergoingthroughallthesewefoundthatth ereisstillalottobedoneinthisfield,asonlytwentyperce ntoftheglobalelectronicwasteisrecycled.Oneofthem ajorproblems isthelackofawarenessinpeopleandthehighcostneede dforpropere-wastetreatment.Fornow, itwillbebettertotryandavoidthe productionofwasteratherthanfindingwaystotreatit.F orthistohappenthelifetimeofproductsshouldincrease andrepairsshouldbeencouragedinsteadofbuyingnew product.

Keywords:E-waste,WEEE,EnvironmentalImpacts,Environmenta lSoundManagement,Recycling.

I. INTRODUCTION

Ewastestandsforalltheoldanddefectiveelectricalande lectronicdevicesandcomponentsaresupposedtoberec ycled,reused,orsimplytobethrownaway.Ewastecom prisesdiscardedmobiles,laptops,computers,televisio ns,etc.Electronicwastecontainsdifferentandmanyha zardoussubstancessuchasheavymetalswhicharetoxic foroursurroundingsandaswellasus,thusit'snecessary todealwithElectronicwasteadequately.Thefollowing tableshowsdifferentcategoriesofe-waste.

Category	Examples
TemperatureExchangeEquipment	AirConditioners,Refrigerators, etc.
Screens	Monitors,laptops,notebooks,televisions,etc.
Lamps	LEDlamps,FluorescentLamps, etc.
LargeandSmallEquipment	ElectricStoves,WashingMachines,ClothdryersCalculat ors,ElectricKettles,microwaves,etc.
SmallITandTelecommunicationEq uipment	Routers,MobilePhones,etc.

Inthelasttwodecades,theworldhasseenahugedevelop mentintechnologyandasaresult,mobilephonesandvar iouselectronicdeviceshavebecomeanintegralpartofo urlives.Overtheyearsthequantityofewastehasincreas edatanalarmingrate.Henceitmustbeourpressingconc erntodealwithewasteinanecofriendlyway.Nowthew orldistakingthisproblemseriouslyandvariousstepsha vebeentakenforthesameyetttheresultsarenotthatenco uragingwithonly20%oftheglobale-wastebeingrecycled.Poormethodslikelandfillingand incinerationarebeingusedinmanydevelopingnations causingseveredamage.Also,lotsofmoneyisneededfo rdevelopingproperinfrastructureforewastemanagem entwhichisthemainreasonforitspoormanagement.E wastealsocontainspreciousrawmaterialswhichgetwa stedduetopoorrecyclingratehencee-wasteisalsobadfortheeconomy.Somedevelopedcoun trieshaveadoptedsomelawsandregulationsforthe

propertreatmentofewaste.PoliciessuchasERPandPROareencouragednowadays.Companieshavealsostartedtousesafermaterialsformakingproducts.Wehavetriedtostudythe overallsituationofe-wasteintheworld.Thegoalofwritingthispaperistomakethereaderunderstandtheproblemduetopoore-wastemanagementandalsomakethemunderstandthevariousilleffectsofe-waste.Thereaderwillbeabletoknowwhathasbeendonesofarfortacklingtheproblemandhe/shecanthinkofnewandbetterwaystotreatmentofe-waste.

II. LITERATUREREVIEW

GeorgiosGaidajis[1]studiedvariouselements,compounds,andothermaterialspresentinelectronicequipment,estimatetheirglobalestimationandpossibleharmfulcausesbytakingseveralewastesamples,andstatesthattheproductionof"halogenfree"appliances,notcontributingtotheproductionofPCBsanddioxins.MinistryofEnvironmentandForest
[2]intheEwaste(ManagementandHandlingRules)statesthatelectricalandelectronicequipmentdoesnotcontainLead,Mercury,Cadmium,HexavalentChromium,polybrominatedbiphenyls,orpolybrominateddiphenylethers.PeeranartKiddee[3]studiedvarioustoolsthatcanbeusedtomanagetheewasteandsuggestedsometoolslikeLifeCycleAssessment(LCA),MaterialFlowAnalysis(MFA),MultiCriteriaAnalysis(MCA),andExtendedProducerResponsibility(EPR)manageewaste,especiallyindevelopedcountries.
SukeshiniJadhav[4]studiedaboutimproperrecyclingprocessthattakesplaceintheinformalsectoralsomentionedtheirharmfulcausesandeffectsandstatesthatIndividualconsumersshouldpromoteeffectiveewastemanagementbymitigatingtheroleofthescrapyardandBangarwalasintheewastevaluechainandpromoteawarenessamongthepeersaboutpropere-wastemanagementbywordofmouth.
C.P.Forti[5]in"TheGlobalEWasteMonitor2017"Categoriesewasteinsixcategoriesandalsostatesthateachproductofthesixewastecategorieshasadifferentlifetimeprofile,whichmeansthateachcategoryhasdifferentwastequantities,economicvaluesaswellaspotentialenvironmentalandhealthimpactsifrecycledinappropriately.Dr.S.Chatterjee[6]studiedaboutrecyclingprocessandtechniquesthathavebeentakingplaceinorganizedandunorganizedsectorandmentionedanapproachforIndianewastemanagementisthatanunorganizedsectortoconcentrateonthecollection,dismantling,segregationwhereasthemetalextraction,recyclinganddisposalcouldbedonebytheorganizedsector.
P.Kidee[7]studiedvariousharmfulsubstancespresentinewasteanddescribestheeffectsofthesameontheenvironment.Suggestedsomestrategies
Variousmethodshavealsobeendiscussedfore-wastemanagementsuchas(LCA, ERP, MCA).
I.CNormon[8]describesthepracticeofEPRindetail.Thereisacompletedescriptionofvariouscomponentsof EPRandhowitisimplementedinvariouscountries.Theyhavealsodiscussedthe WEEEdirectiveanditsimplementation.Forthis,
theystudiedthelegislationsinSwitzerland,
Japan,Taiwan,Finland,EUandthenlookedatdevelopingcountries.ItwasfoundthatWEEEisfunctioningeffectivelyin
theEU.Itisrecommendedthatthereisaneedtoimplementing WEEEproperlyindevelopingcountriesbylearningfromthesysteminthe EU.
PrasannaKumar[9]estimatedtheamountofewasteandalsostudieditsmanagementinthecityofMangalore.Forestimation, thereisthe useof the marketsupplymethodinwhichthedataofsalesandlifespanofe-
productsisused.Thestudyconcludesthatthereisnoproperimplementationofewastemanagementpoliciesinthecity.Italsosuggeststhattheproducertake-backpolicyisthebestmethodforthe managementofe-waste.
D.sinha[10]comparesthescenarioofe-wastemanagementinIndiaandSwitzerland.InSwitzerland,thepolicyforewastemanagementisbasedontheprincipleof“PolluterPays",whilenosuchthingisimplementedinIndiaproperly.VariouslegislationsusedinSwitzerlandarestudiedindetail.InIndia,mostoftheewasteistreatedintheinformalsector.Thepaperconcludesthatthereisahugedifferenceinbothcountriesinthisregard.
KarishmaChaudhry[11]comparestheewastemanagementsystemsinIndia,Germany,Japanbyusingaradarchartmethodology.Thestudyfindsthat Indiaislaggingfarbehindtheothernationsinewastemanagementdespitebeingalargeproducerofe-waste.Thestudydiscoveredtheloopholesin theIndian systemandalsosuggestedsomepossiblesolutions.
XiaHuo[12]studiedthecaseofGuiyuanewastemanagementsiteinChina.thestudycomparedthemeanBlood LeadLevelinasampleofkidsbelow6fromGuiyuandChendian(aneighboringtownwithoutanwastedisposalplant).Thestudyfoundexponentiallyhigh BLLinthechildrenofGuiyuduetotheewastedisposalplant.Dr.SChatterjee[13]discussedthewholesituationofe-wastemanagementinIndia.Firstlythereisthe state-wisedistributionofe-
wasteproducedinIndia,thenthereis the city-wisegenerationofe-
wasteinIndia.Thepaperestimatesthetotalamountofe-wasteproducedinIndiaandalsopredictsthefuturetrendsofe-waste.Thereisalso a descriptionofthe globalscenarioofe-waste.Finally,
thereisdescriptionofe-wastemanagementpracticesinIndia.Thepaperconcludesthatmoste-wasteinIndiaistreatedinthe

informalsectorwithoutproperrules.Thereisaneedfproperlegislationfore-wastemanagementinIndia.
RonaldGeyer[14]discussedtheeconomicapproachofreuseandrecyclingofcellphones.The number ofrawmaterialspresentinacellphone is presentedinthepaper.Thestudyisbasedupontheuseof datacollectedbyreverselogisticsfromthe U.SandU.K.Thereverselogisticsofcellphonerecyclingcurrentlyappearstobeentirelyfinancedbycellphonerefurbishersandcouldthusberegardedasabyproductofcellphonereuse.Onitsown,cellphonecollectionandrecyclingcouldneverbedoneprofitably,evenifreverselogisticscostsweretobeminimized.
X.Chi[15]discussedtheinformalsectorofe-wastemanagementexistinginChina.Forthisthegroup collectedthedataofformale-wastecollectionandcomparedwiththe informalsector,theresultsclearlyshowedthatthe informalsectoristhemajorplaceofe-wastedisposalinthecountry.Thepaperthendiscussesthereasonsforthesame.Itwasconcludedthatthe informalsectorprovides a door-to-doorcollectionofe-wasteandisalsothesupplierofsecondhanddevices,thesethingsarenotthereintheformalsector.
J.Wang[16]studiestheeffectofparentpolycyclicaromatichydrocarbons(PAHs),highmolecularweightPAHs(MW302PAHs),andhalogenatedPAHs(HPAHs).Thestudyconcludedthatlifetimeexposuretothesecompoundsmayleadtocancer.Forthestudy, atowninsouthChinawasobservedandcomparedwithanurbantown.Itwasfoundthatintheruraltownthepeoplehadhighchancesofexposuretothesechemicalsduetothepresenceofe-wastedismantlingsitesinsouthChina.
V.Sahajwalla[17]studiedtherecyclingofplasticsine-waste.Thepapertellsthattherecyclingofe-wasteplasticisnotpossiblelargelyduetothepresenceof Brominatedflameretardants.Thepaperalsotellsabout newtechnologiessuchasmicro-factoriesandstatestheirlimitationsandprospects.
RamKrishna[18]studiedICTdevicestheir lifetimesetcanddiscussedthatreuseofEEEhasgreater environmentalandsocialbenefitthanrecyclingasitincreasestheusefullifetimeofICTequipmentandenablesgreaterresourceefficiencyandenergyefficiency.
AmitKumar[19]surveytofindoute-wasteawarenessamongstudentsoftwodifferentbackgrounds i.e.studentsfrom a professionalstreamandnon-professionalstream.Afterconductinga surveyheconcludes that"studentsof the professionalstreamarehavingmoreawarenessofthe riskofe-wastethana studentofa non-professionalstreamandstudentsofbothstreamsareunawareofpropere-wastemanagement."
SaiLakshmi[20]studiedvariousmaterialspresentinelectronicequipmentandtheir possiblecausesandconcludethattoreplaceCRTscreenswithLCDscreens, the introductionofopticalfibertolead to Cueliminationfromcablings, etc.
M.D.JalalUddin[21]studiedallpossibleelements,compoundspresentinelectronicequipmentlikelead,mercury,arsenic,cadmium,selenium, andhexavalentchromium, etc, andtheirusesin the manufacturingofelectroniccomponentsalongwiththeirharmfuleffects.
TetianaShevchenko[22]researches andexplorestheincentivesthathavebeenusedtoincreaseconsumercollectionratesforend-of-lifeelectricalandelectronicequipment(EoLEEE)and hisresearchsuggeststhatimplementinganeconomicincentivebasedontheelectronicbonuscardsystem(EBCS)hasseveralbenefitscomparedtoexistingincentives.
M.KhurrumS.Bhutta[23]estimatethee-wastecollectioninwhichMicrosoftExcelwasusedtoapplylinearregressiontechniquetopredictthenumberofunitsandthetonsofe-Wastegeneratedandpredictthee-wastegenerationratefortheupcomingyears.
MadeleineBrannon[24]studiedonvariousinfrastructuretoincreasethetimeusageofe-wasteandanalyzedanalternativearchitecturethatcouldpotentiallyencourageandinspirescustomerstokeepmobiledevicesforlongerdurationsandexploredtheideasofphonebookandmodulardevicestoallowa consumertoreplaceapieceofthephoneratherthanthe entirephone.
ManMohitSingh[25]studiedEuropean,Japanese, andIndiane-wastemanagementsystems indetailandgavethecomparisonofthedifferentaspects ofe-wastelegislationfromEuropeanUnion(EU)andJapan IndianRegulationandsuggestvariousreformsthatcanIndiane-wastemanagementsystemshouldadopt.
LiJian[26]studiedaboutExtendedProducerResponsibilityprincipleindetailanddiscussedtheintroductionofEPRsystemintothee-wastemanagementsystemtoreduceelectronicpollutants using theestablishmentofresponsibilityofthemainfore-wasterecyclingdisposal.
RamachandraT.V.[27]studiedvarioushazardoussubstancespresentine-wasteandsuggestedthatminimizationofhazardouswastesshouldtakeplaceatthe productdesignstagebykeepingthefollowingpointsinmind.1.Rethinktheproductdesign.2.Useofrenewable materialandenergy.3.Useofnon-renewablematerials thataresafer.
S.V.A.R.Sastry[28]studiedvariouse-wastemanagementminimizationtechniquesandsugg

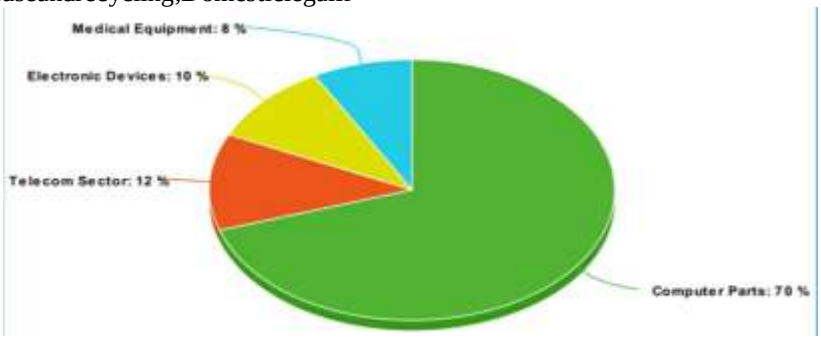
International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 5 May 2021, pp: 531-547 www.ijaem.net ISSN: 2395-5252

estedthatwasteminimizationinindustriesinvolvesadoptinginventorymanagement,production-processmodification,volumereduction,recovery, andreuse.
Shagun[29]studiedthepresentscenarioofe-wasteinIndiaandproposedsomesolutionlikeRewardandreprimandschemesforperformanceandnon-complianceofe-wastemanagement,Imparttrainingtogeneratorsone-wastehandling,Awarenessprogramonrecycling,Promoterecyclingunitstoeasethe processandtoencouragegeneratorstohaveproperee-wastedisposal,Linkupactivitiesofthe informalsectorwith the formalsector,TheFrameworkshouldaddresstheissue ofE-wasteimportsforreuseandrecycling,Domesticlegalframeworktoaddressthesegapsinthe importofE-Waste,Thenmakesurethecompanyyouselect can handleeithertypeofE-Scrap.
YenmingJJChen[30]studiedaboutrecyclingfragmentationtradealsodiscussedthepatternofrecyclingfragmentationtradeandgavethepositiveandnegativeeffectsofrecyclingfragmentationtradeforbothexportingandimportingcountries.

III. E-WASTE ESTIMATION:

A.IndianEstimation

Indiaisagrowingnationandastechnologyisadvancing likewisethequantityofe-wasteisrisingat a dangerousrate.Currently,Indiaisoneofthemajorproducersofe-wasteandrankedin5th positionglobally.[38]



Graph:%ofE-wastegenerationfromdifferentsources.[38]

Asthechartshowsthemajorsourceofelectronicwastein Indiaisdiscardedcomponentsofcomputersandlaptops,smartphones,etc.Accordingtothegovernment,thereareabout1billionactivemobilephonesinIndia.Many oftheproductsandtheircomponentsarereusableandarerecycledbutitismostlydoneinformallybywaste-pickers,asallthisrecyclinganddisposalisdoneoutside ofanyorganizationitbecomesreallydifficulttoimplementanykindoflawforpropertreatmentofe-waste.Almost90%oftotalelectronicwasteinourcountry(India)istreatedbythe unorganizedsectorininformalwaysresultinginahugeriskofcontaminationoftheenvironment.

InIndia,about75%oftotale-wasteisproducedbygovernmentandprivatecompanieswhiletheshareofindividualhouseholdsisonlyabout15%.ASSOCHAM,anindustrialbodyofIndiahaspredictedthatby2020Indiawillbeproducingabout5millionton sofe-waste.[38]
Theamountofe-wasteproducedvariesfromstatetostateacrossIndiawithMaharashtrabeingat the firstspot.AsIndiaisbecomingricherdaybydaypeoplearebuyingmoreandmoreelectronicdevicessuchascomputers,smartphones,microwaves,refrigerators,televisions,etc.,resultinginmoreandmoree-waste.

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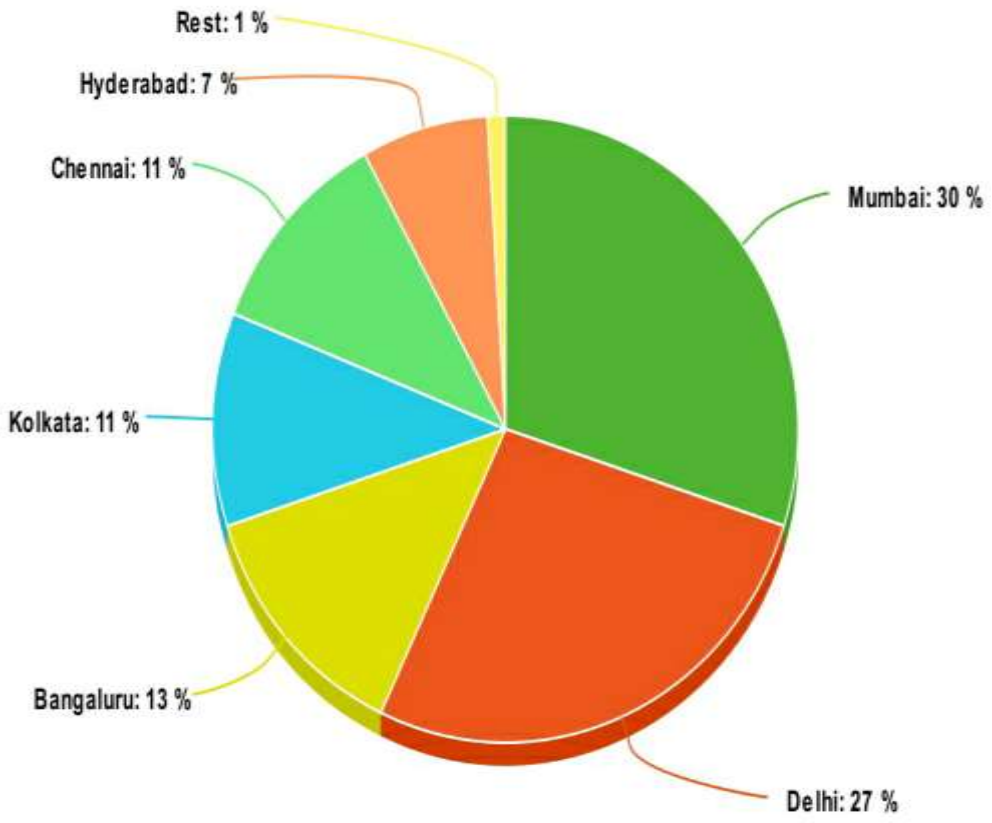
ThefollowingisachartshowingtheamountofE-wasteinsomemajorcitiesinIndia.[39]



Only5%ofallthee-wasteproducedinIndiaisrecycled,thereasonbeingpoorinfrastructureandimproperimplementationoflaws.E-wastegenerationinIndiatouchesthemarkoftwomillionnesevery yearandtherecycledquantityisonly4,38,085TPA**[42]**

State	Units	Capacity(tonnes)
Karnataka	57	44,620
Maharashtra	32	47,810
UttarPradesh	22	86,130
Haryana	16	49,981
TamilNadu	14	52,427
Gujarat	12	37,462
Rajasthan	10	68,670

Currently,inIndia,therate of electronicwasteisgrowingis4.5timesthetotalprocessingcapacityofthenationwhichresultsinunorganizedanddillegitimatedisposalofe-wasteandtheconsequencesofthisunauthorizeddisposalarecontaminationoftheenvironmentaroundthedisposalsite.Manyoftherichcountriesimporttheire-wastetoIndiaforrecycling.

B.GlobalEstimation:

Ewastediffersfromotherkindsofsubstantialwastesasitincludesbothhazardousandusefulsubstances.Recyclingofusefulsubstancescangeneratealotofmoneyandthereisalargemarketbasedonrecyclingespeciallyindevelopingcountriesbutthisrecyclingshouldbedoneproperlyfollowingproperrulesandregulationsasthereisalwaysariskofcontaminationoftheenvironment.Astechnologyisimprovingdaybydayandthereiseverincreasingdemandfornewandadvancedversionsofsmartphones,computers,laptopsfromthecustomersleadingtotheproductionofe-wasteata

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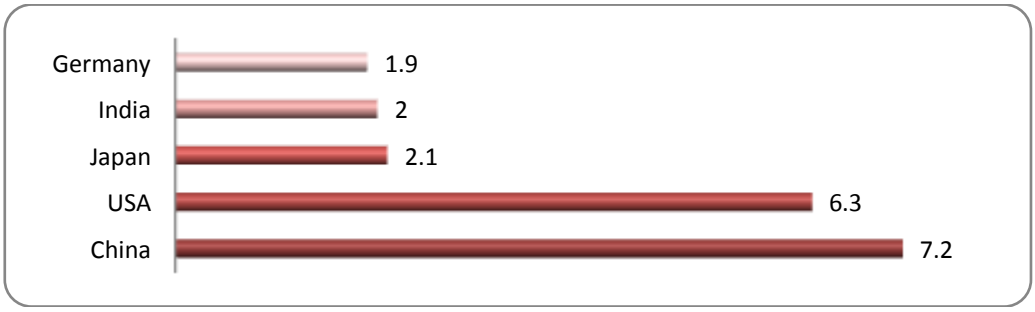
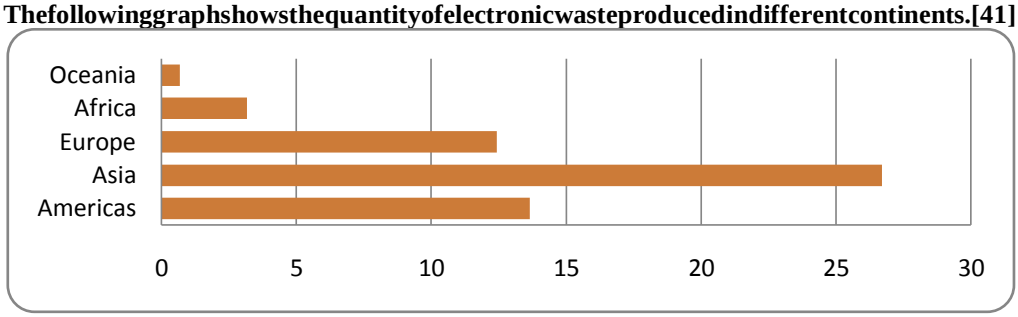
largescalealloverthеearth.Recyclingofe-wasteusuallyrequiresahighamountofmoneysoasares ultalotofcivilizedandadvancedcountriessendtheire-wastetoimmatureandgrowingnationswhereitistreate dinformallywithoutanyrulesandregulations. Itisquitesurprisingtofindthat9outof10leadinge–waste-producingcountriesarelocatedinEuropeandtheUSAd espitetheirlowpopulationascomparedtoIndiaorChin awhichsuggeststhatthepercapitae-wastegeneratedindevelopednationsisquitehighandar easontoworry.



Graph:E-wastegenerated(millionmetrictonnesperannuminsomemajorcountries).[41]

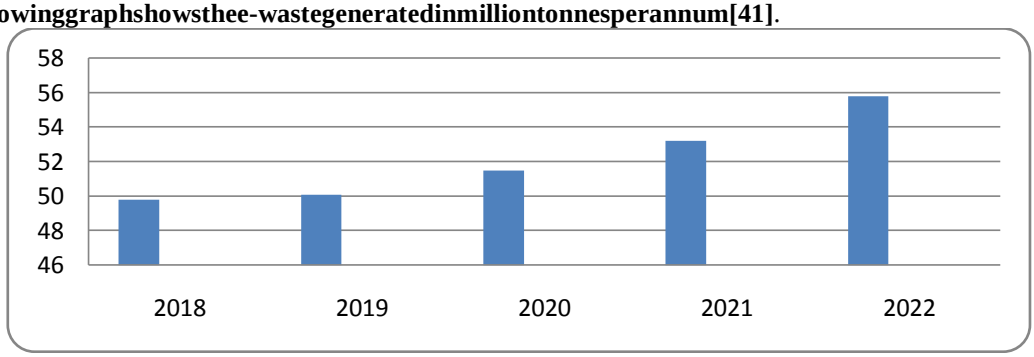
ChinaandIndiaaretwoofthemostpopulatedcountriess otheirpercapitae-wasteisnotthatsignificantthеrealworriesarecountries likeGermanybecausetheirpercapitae-wasteisquitesignificant.Thereasonforthisissimplybe causeofthehighstandardsoflivinginEuropepeoplethe redon'tcompromisewiththeircomfortsandtendtochan gegadgetsfrequentlycomparedtootherdevelopingco untries.Butatthesametime,theEuropeannationsarequ iteefficientinrecyclingtheire-wasteastheyrecycleabout47%oftheire-wastecomparedto5%inIndia**.**

Thefollowinggraphshowsthequantityofelectronicwasteproducedindifferentcontinents.[41]



Therehasbeenaboomintheelectronicsmarketinthelas tdecadeinAsiancountrieswithIndia,China, andJapanleadingthesalesandproductionwhilethispro vedtobeeconomicallybeneficialbutalsoposedthepro blemofproperlytreatingthewastegenerated.Studiessh owthatshortlythegrowingcountrieswillbeproducingt wicethequantityofe-wasteascomparedtofullygrownnationsalsotherichco untriestransporttheire-wasteillegallytoAfricanandAsiancountriesfordispos alinlandfillswhichisaseriousconcern.

Thefollowinggraphshowsthee-wastegeneratedinmilliontonnesperannum[41].



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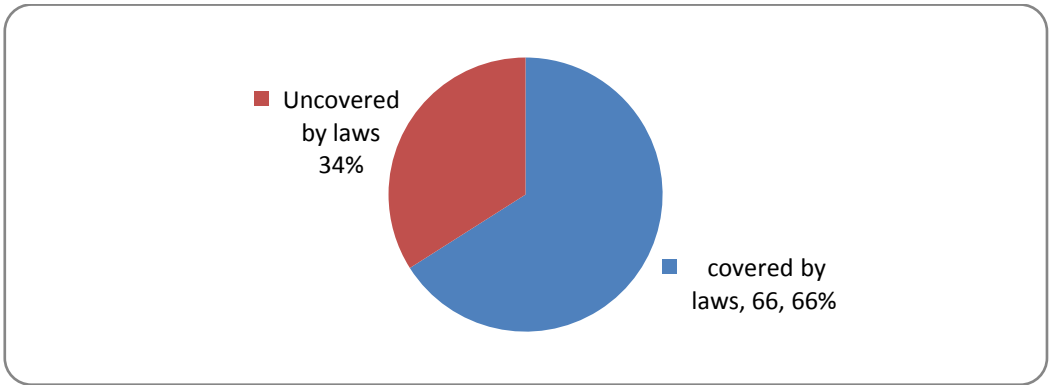
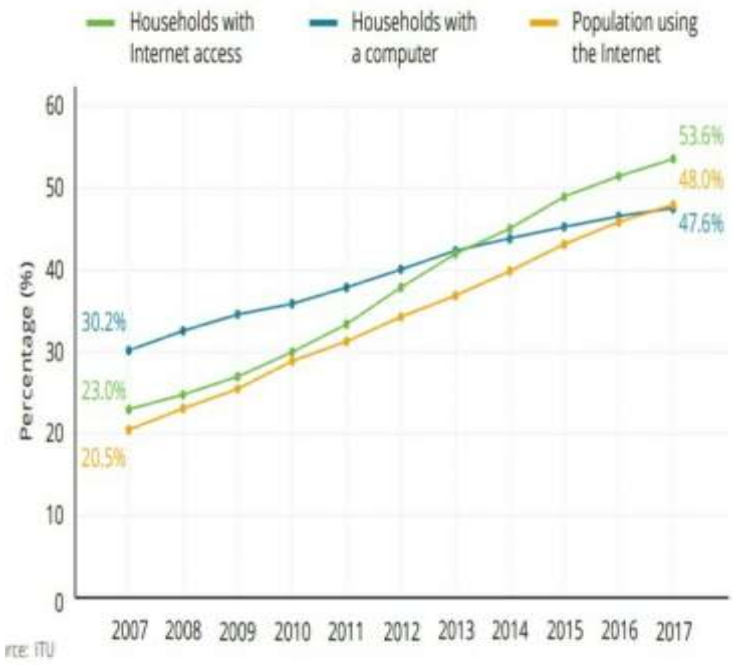
Nowslowlymajorityofnationsareimplementinge-wasterulesandregulations.Morethanhalfofthe world'spopulation(nearabout66%)isfollowingtheser ulesandregulations.In201767countrieswereretherewhi chadoptede-wastelegislation[41].



- TheglobalITsectorandthe electronicsectorisdevelopingata highpace.Varietyofnetworkswithhighspeed,pro misingapplications, andserviceswhicharegrowingat a veryhighrate,havebroughtfreshchancesandgood timestomanyindividualsandorganizationsmostl yinthefieldofhealth,education,government,dem andforelectronicgoodssignificantlyincreasesfor dailyworksalongwithelectronicgoodsuseofthein ternetalsoincreasing.Today3.6billionofthe totalworld'spopulation("7.4billion"totalpopula tionofthe world)using the internettodayentertainment,andcommerce.Asar esult.



Graph:%ofhouseholdswithinternetaccessandcomputerand%ofthepopulationusingtheinternet[41]

Sobasedontheabovestudiesandestimationsthequantit yofe-wasteproducedisgrowingeverydayandisexpectedtoc ross60milliontonnesgloballyby2025.

IV. IMPACTSOFE-WASTE ON HUMAN HEALTH, ENVIRONMENT, AND SUSTAINABILITY.

A.PossibleHazardousSubstance

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E-wasteisincreasingexponentiallyduringthe pastdecadeduetotheincreasedneedsandrequiremento felectronicdevicesworldwide,theconditionindevelop ingcountrieslikeIndiaisevenworsewheree-wastemanagementtechniquesandlawsarenotuptothe requiredstandardsandhencee-wastecontaminatesthewholeecosystem.

Pollutants	Majorsource
Cadmium	Computerbatteries ,Cathoderaytubes
Lithium	Mobiles,elements usedinphotograph y
Mercury	LCD's,Batteriesin watchesandcalcul ators
PCB's(polychlorinatedb iphenyls)	Capacitors,Transf ormers
Silver	Switchesandresist ors
Nickel	Semiconductors,B atteries
Barium	Electrontubes
Cobalt	Insulators
Lead	Stabilizers,LED's, Circuitboards
Selenium	PhotocopyandXer oxmachines
Chromium	Themetalcasingof manye-products

Table:ShowstheharmfulsubstancepresentinE-waste.[40]

Themajormethodsusedforthe disposalofe-wasteindevelopingnationsarelandfillsandtheburning ofe-wastebyvariousmethods,bothofwhichareresponsible forcontaminationoftheenvironment. Whenewasteisusedinlandfillstheharmfulsubstances presentpassoninthegroundwaterandsoilandhenceent eringthefoodchain.Whenthewasteisburntintheairthe nthepollutantsreachtheatmosphereandpollutetheair. Bothoftheabovethingsresultincriticalhealthproblem sfortheworkersinthedisposalsitesandthepeopleliving nearthesesites.

B.ImpactsonHumanHealth

1.Leadpresentine-wastecandamagethereproductivesystem,nervoussys tem.Itisverydangerousforyoungkidsandisresponsibl eforthepoordevelopmentofthebrain.
2.Cadmiumcandamagethekidneyandalsocanleadtob onediseases.
3.Mercury,wheninhaledinlargequantities,leadstoda magetothe nervous,digestiveandrespiratorysystems.
4.PVCsapotentialairpollutantanditcausesrespiratory problems.
5.Nickelcanleadtolungcancerandbronchitis.
6.Barium,whenexposedinlargeamount,causesbrains welling,damagetoheartandliver
7.Seleniumleadstoadiseasecalledselenosis.
8.Chromiumcanleadtoirritationinthenose,throatandi sknowntocauselungcancer.

C.EffectsofE-wasteProcessonEnvironment.[33]

Ase-productsarecomposedofbothvaluableaswellashazar doussubstances,itrequiresadvancedtechnologymeth odstodealwiththewastegeneratedtoincreasetherecov eryofusefulmaterialsanddecreasetheharmfuleffectst othesurroundings.Butthefactisthesespecialmethodsr equireaveryhighcostandinfrastructurewhichisnotava ilableinmostofthecountriesintheworld,eventhedevel opednationstendtoshyawayfromspendingthismucha mountontreatmentprocessesinsteadtheytransportthe ire-wastetootherpooranddevelopingnationsforrecycling .Indevelopingcountriesthereisnoinfrastructure,prop erlegislationfore-wastemanagementneitherthecitizensareawareoftheh armsofe-waste,mostofthetreatmentofe-wasteisdoneinthe informalsectorbyindividualpersonsoutsideofanyorg

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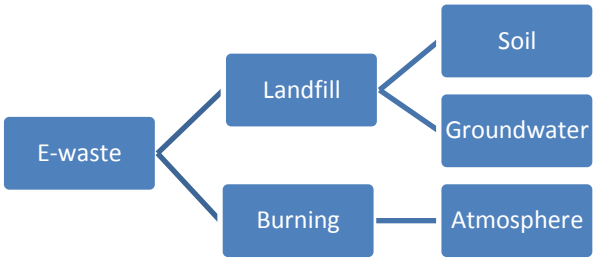
anizationandwithoutanylimitations,asaresult,thereis the useofharmfulmethodsforthetreatmentofe-waste.Someofthemethodsarelistedbelow-

Landfilling-
Itisoneofthemostfrequentlyusedmethodsofe-wastedisposalinpoorcountriesinthismethodtrenches aredevelopedbydiggingthesoiloflevel andthenthewasteisburiedinthesetrenchesand is coveredbysoil,inmostofthelandfillstherearenoarrangementsforthecollectionofleachateandsendittothewatertreatmentplants.Asaresult,theharmfulsubstancespresentine-wastepassthroughthesoilandreachthegroundwater,thisbecomesdangerousforthepeoplelivingnearthedisposalsitesasthewaterinthatareabecomesunfitforuse.Farmingshouldbeavoidedinsuchanareaasthepollutants canenterthefoodchainthroughthecrops,thuscausingsevere healthproblemsforbothhumansandanimals.Thismethodalsotakesalotoftimeforthedegradationprocesstotakeplace.

Incineration-
Inthismethod,thewasteproductsareburntundercontrolledconditionsatelevatedtemperatures(about1000degreesCelsius).Thismethodispreferredbecauseitresultsinareductioninthequantityofwasteanditisveryfastcomparedtolandfilling.Butthismethodisalsonotadvisableasthepollutantsinthee-wastearedispersedinthesurroundingsresultinginthecontaminationoftheatmosphereareoundthedisposalsites.Exposuretothisairforalongtimeresultsinvariousbreathingandhealthproblemsfortheworkersandthelocal citizens.

Recyclingofe-waste-Manyofthee-wastehavesomepartsandmaterialswhichcanbeextractedandreusedfurtherforex-metalssuchasironandcopperusedinthebodiesofmanye-productscanbeextractedforfutureusewhichisgoodfortheenvironment,butappropriatemethodsshouldbeuseddforrecyclingprocessandthecostfortheinfrastructure requiredishighasaresultmostofthecountriesarenotabletorecycletheirwaste.Poortechniquesareusedfortherecyclingofe-wastewhichleadstoairandsoilpollution.

Reuse-
Thisreferstothedirecttransferofausedproducttoanotherpersonatacheaprateforsecond-handuse.Therearesecond-handmarketsindevelopingcountriesandareaprimesourceofincomeformanypeople.Thisshouldbemotivatedasitwillreducetheproductionofwasteandalsowillreducethedemandfornewones.



D.CaseStudy[45]
Intheyear2008,asurveywasconductedinsoutheastChinatoknowtheimpactsofheavymetalsonhumanhealth.Guiyu,asmalltowninsoutheastChinaisknowntobetheworld'slargeste-wastetreatmentsite.Samplesofsoilwerecollectedfromdifferentlocationsofthetownandwereexamined.Thefollowingthingswerenoticed-

1. HighlevelsofPbandCuwerefoundattheschoolyard.
2. Neartheworkshops,therewerehighlevelsofZn,Cu,Pb.
3. HighlevelsofNiwerealsorecordednearttheschools.
4. Nearthefoodmarkethighlevelsof Cu,Ni,Pb,andZnwerefound.
5. ThelevelsofPbandCuinroaddustwere330and106timeshigherthanthenon-e-wastesites.

Theaboveresultscausedapanicbecausethefoodwasmostlyexposedtothecontaminateddust.Thelevelofthelead present was very high which possessed the danger of lead poisoning in children below the age of 6. Lead poisoning results in brain damage and poor development of the body. The workers in the disposing sites suffered various breathing and lung problems.
Thebloodleadlevels(BLL)wererecordedforasampleof226children(age<6)livinginGuiyuandnearbytownChendian(where-wastedisposaldoesnottakeplace).Onanalysingthesamplesthefollowingobservationswerenoted-

1. ThemeanofBLLofchildrenofGuiyuwasfoundtobe15.3unitscomparedto9.94unitsofchildrenofCanadian.
2. Theanalysisshowedthatchildreninguiyu81.8%hadBLL>10unitscomparedwithonly37.7%inCa

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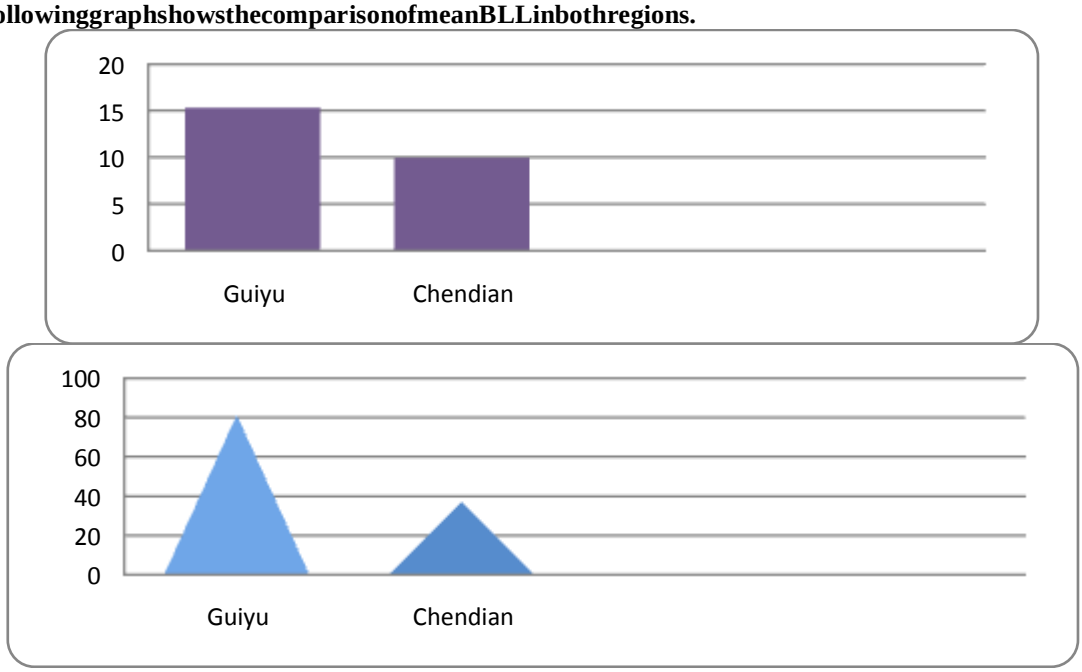
nadian.ABLLgreaterthanorequalto5isconsidere ddangerousforyoungchildren.

ThefollowinggraphshowsthecomparisonofmeanBLLinbothregions.



Theabovegraphshowsthe%ofchildrenatbothplaceshavingBLL>10µg/dL.
Itisclearfrombothgraphsthatthelevelsofleadinthechildren ofGuiyuarequitehighascomparedtothenearbyregionChendian.Thestudysuggeststhate-wastedisposalsitesinGuiyuareresponsiblefortheincreasedlevelofleadinchildrenbelowtheageofsixmakingthempronetoleadpoisoning.

E.Economicimpact:
E-productscontainvarioustypesofrawmaterialssuchascopper,iron,steelwhichcanbeextractedfromthewastegeneratedaftertheendoflifeoftheproducts.Thefollowingisacasestudyabouttheeconomicimpactofe-waste.

Assmartphonesarebecomingpopulardaybydayandnewversionsarelaunchedinthemarketfrequentlyencouragingpeopletochangetheirphones.Thisresultsinalargequantityofe-wastewhichleadstowastageoflargeamountsofrawmaterialswhichcouldhavebeenreusedandthecostoftheirextractionfromEarthcouldhavebeensaved.
i-phonesbecamequitepopularinrecenttimes.Areportsuggestedthatthenumberofi-phoneusersinIndiawillbeabout10millionbytheyear2020.
Theproductionofonei-phonerequiresmanyrawmaterialswhichareshownbelow-

[43]Thetotalweightofamodelofi-phone6is129gramswhichconsistsof-

Material	Weightingrams
Aluminium	31.1
Carbon	19.9
Oxygen	18.7
Iron	18.6
Silicon	8.1
Nickel	2.7
Copper	7.8
Cobalt	6.6
Hydrogen	5.5
Chrome	4.9
Others	4.9
Total	**129**

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Nowoutoftheabovematerials,ironandaluminiumarep rimemetalsthatmakeupthemajorpartofthebodyofthes martphone.Ifsomehowwecanextractallthealuminiu mandironpresentin the i-phonewecanget31.6gofAland18.6gofiron. Nowaspointedearlier,approximateusersofi-phonesinIndiaby2020are10million,whentheseusers willchangetheirphones,therewillbealargenumberofo ldphonesintheformofe-waste.

Totalquantityofaluminium=10000000*31.1=316, 000,000g=311,000kg
Totalquantityofiron=10000000*18.6=186,000,00 0g=186,000kg
Asonecanseethismuchamountofrawmaterialgetswas tedduetopoorextractiontechniques.Theoresofthesem etalsareinlimitedquantityontheEarthsowehavetouset hemwisely.
ThecostofAluminiumandIronusedinthei-phoneisapproximately$0.055and$0.002,respectivel y[45].ConvertinginrupeesitcomesouttobeRs3.90and Rs0.14respectively.
Thetotalcostofaluminuimpresentin10millioni-phones=Rs39crores.
Totalcostofironin10millioni-phones=Rs14lakh.
Goldandsilverarealsopresentini-phonesinsmallquantities.Therespectivequantitiesofg oldandsilverare0.034and0.34grams.Thecostofgoldi nonei-phoneis$1.82.

Thetotalquantityofgoldin10millioni-phones=10000000*0.034=340kg

Thetotalquantityofsilverpresentin10millioni-phones=10000000*0.34=3400kg.
IfwecalculatethecostofthesemetalsaccordingtoIndia nprices-
Gold=Rs1,360,000,000=136crores.
Silver=Rs132,600,000=13crores26lakhs.

ApproximatelyrawmaterialworthRs200canbeextrac tedfromthetreatmentoftotali-phonespresentinIndia.(**forthisstudyi-phone6versionisconsidered)**
Theabovestudyonlyconsidersthei-phone,whichconsistsofaverysmallportionofthetotale-wastegeneratedinIndia.Ifweconsiderallthecellphone s,laptops,computers(themajorsourceofe-waste)inIndiathenthenumberofpreciousmetalsandth eircostwillbemorethantheannualbudgetofsomecount ries.
Bytheaboveapproximations,itcanbesaidthattheelectr onicgadgetswhichweareusingareveryprecious.After theusefullifeoftheproducts,thereshouldbeaprocessto extracttherawmaterialsinaneconomicalandeco-friendlyway.ByextractingthesemetalsIndiacansavea lotofmoneywhichwillbespentontheextractionofthes emetalsfromtheirores,itwillbegoodfortheEarthasmin ingwillbereduced.Byrecyclingproducts,therewillbea waste reduction.Itcanalsobesaidthate-wasteisnotawaste,itcanbearesourceiftreatedproperly .

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V. E-WASTE MANAGEMENT– CURRENT SCENARIO

A.Europe

"IntheEuropeanUnion,electronicwastehasbeenmentionedin the context of reducingenvironmentalpollution,forcontaminatingthe naturalresourcesandalso reducing its usefor landfill purposes.

Therulesandregulationsmadebytheparliamentarebasedonthreeprinciples,theprevention,recycling, andthereuseofe-waste,sothetotalamountofthewasteelectricalandelectronicequipmentisreduced.

Theaboveiselaboratedintworelativedirectives.AdirectiveisalegalactoftheEuropeanUnionthatrequiresmemberstatestoachieveaparticularresultwithoutdictatingthemeansofachievingthatresult".

1)(RoHS-Restrictionofhazardoussubstance)Directive2002/95/EC. Itstrictlyprohibitstheuseofdangeroussubstancesforhumansandthe environmentbyintroducingtheneedforthechangeofthesubstancescausingmainenvironmentalissueswhilethereusingandrecyclingofwasteelectronic&electrical equipment.AccordingtoRoHS,themosteffectivemethodforthesubstantialdecrementofhealthandenvironmental hazardsrelatedtotoxicsubstancesistheirreplacement withothernontoxicsubstances.Thebanontheuseoftoxicsubstancesismostlikelytoincreasethenewwaysandthefinancialprofitfromrecyclingelectricalandelectronicproducts.

2)WEEEDirective[34]: ItistheEuropeanorganizationsinitiative2002/96/ECon a wasteelectricalandelectronicproductwhich,together withtheRoHSregulations2002/95/ECwhichimplementedasEuropeanlawinFebruary2003.TheWEEEinitiativesetcollecting,recycling, andrecoveryofalltypesofelectronicgoods,withrateof4kgpopulationperannumrecoveredforrecyclingby2009.ThesymboladoptedbytheEuropeanUniontorepresentWEEEisas.

ExtendedProducerResponsibility(ERP).Itfocuses on :

a)Theresearchanddevelopmentofelectronicequipmentare going to supportdisperseandrecovery forreuse in the futureandrecyclingofe-waste.

b)E-waste should be treated differently from other kinds of wasteandtheircollectionshouldnotburdenhouseholds.

c)Management of E-waste should be financed by the organizations which are in the production of electronic goods.

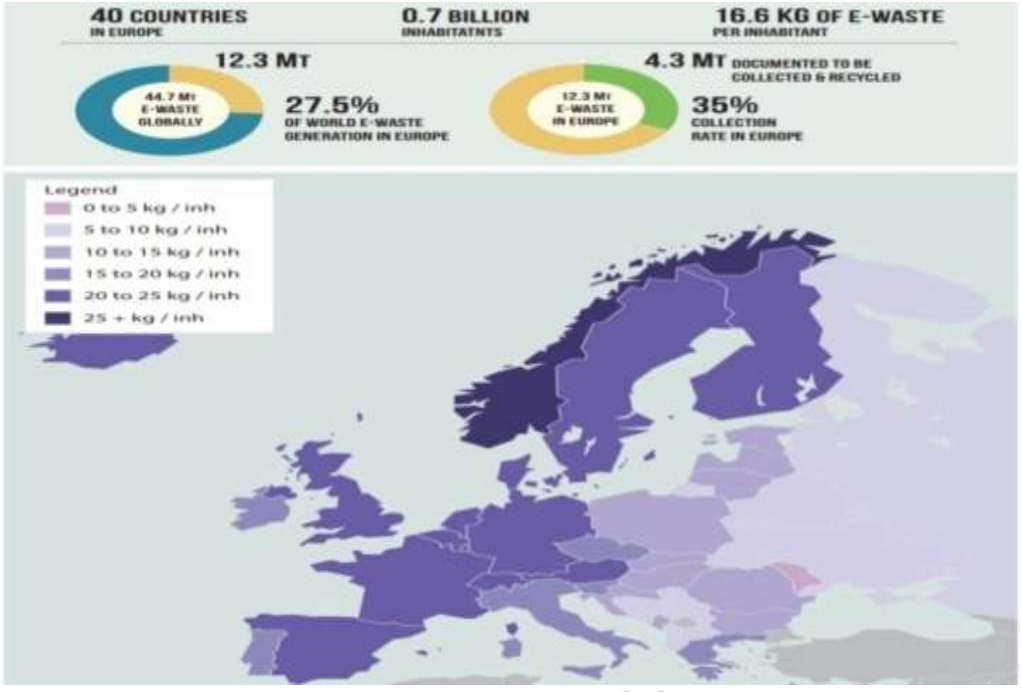

Fig:EuropeanOverview[41]

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B.Japan

In Japan, withdrawal is not free of cost if anyone wants to return the electronic good to the trader, then they have to pay for it.Thewithdrawalsystemis of four typesof e-waste(airconditioners,televisions,refrigerators, andwashingmachines)since1998.There are strict penalties and specific rates for noncompliance in Japan.ThereareseveralrecyclingfacilitiesinJapan,partiallyfinancedbytheministries,municipalities, orJapanesecompaniesproducingelectronicgoods.ProducersinJapancollaboratewithotherproducerstocreateandoperatesuchfacilities.E-wasteinJapanis collectedfromtheresidencewhen it is notusedanymoreorwhenaconsumerbuysanewone.Thecollectede-wastefromresidenceistransportedimmediatelytothee-wastecollectionpointandeventuallytothefacilitiesthroughadisposalsystem.AbasiccharacteristicoftheJapanesee-wastesystemistheuseofprimarydisassemblyproceduresofbigpartsinitiallywithamoreaccurateandbriefprocesssothattheyhandletheresiduesmoreproperly.Asaresult,theJapaneseElectronicequipmentcompanieswerethefirstonestoevolveweldingwithoutinsulationandelectricalpanelboardconnectionswithoutbromidecompoundsabouttheEuropeanguidelinesofthedirectives RoHS,whiletheyhaveconstantlyaimedatthedesigningoflighterweightproducts,cheaperandeasiertoberecycled.Disassemblybyreducingthenumberofplasticresinsintheirproductsandreusetheir partsareinJapaneseproducer'sdemand.In2013,theJapanesegovernmentreportedthatroughly550thousandtonnesofe-wastewerecollectedandtreatedinJapan,whichonlyequatestoabout24-30%ofthetotale-waste.Today,Japanhasoneofthehighestrecyclingratesinallof Asia,butthesenumbersaremorecloselyrelatedtotherecyclingofplastics,paper,andglassofthe650,000tonnesofhomeappliancesandsmallelectronics discardedperyear,lessthan100,000tonnesarecollectedforrecycling.InTokyoOlympics2020Japanusese-wastefortheproductionofOlympicmedals[37].AccordingtotheOlympicCommittee,Japaneseengineerswereabletorecover32kgofgold,3500kgofsilver,2200kgofbronze(95%copperand5%zinc)from78,985tonsofelectronics.Thatfigureincludedastaggering6.21millionoldmobilephoneshandedoveratNTTDoCoMostoresacrossthecountry.

C.India

India has different problems related to E-waste management in comparison to other developed countries.InIndiapracticesofe-wasteisaveryseriousissueduetoimproperrecyclingfacilities.In your country, E-waste is present in large amounts and there are no proper rules and regulations to deal with it.ProbablyinIndiae-wasteisgiventothe“kabadiwalas"whopaysomeamounttothepersonfromwhomtheyarecollectingthee-waste.InIndia,the"kabadiwalas"earntheirlivelihoodbycollectingalltypes of unusable and old materials for e..:papers,books,newspapers,plastics,cardboard,polythene,metalsincludinge-wastebyselling them toscrapdealers.Thesetypeofactivitiesisaverygoodtypeofworkorbusiness“kabadiwalas",middleman,scrapdealertoearntheirlivelihoodtofulfiltheneedsoftheirfamilies.Alargepopulationofuneducatedpeopleisbusyinthisbusinesswithagoodsourceofincome.Asaresult,e-wastein India is mostly managed by unqualified laborers without any safety measures.Duetothelackofknowledge,technology,awarenesstherecyclinganddisposalarenotdoneproperly.InIndia,about75%oftotale-wasteisproducedbygovernmentandprivatecompanies,whiletheshareofindividualhouseholdsisonlyabout15%.ASSOCHAM,anindustrialbodyofIndiapredictedthatby2020Indiawillbeproducing5milliontonnesofe-waste.Only5%ofthetotale-wasteproducedinIndiaisrecycled,thereasonbeingpoorinfrastructureandimproperimplementationoflaws.Thetotalamountofe-wasteinIndiaisabout2milliontonnesperannumandtherecycledquantityisonly4,38,085TPA.Thereareveryfewelectricalandelectronicgoodscompanies inIndiathathaveimplementeda "takeandback"systemvoluntarily.InIndia,theMinistryofenvironmentandforests(MoEF)isthenodalagencyintheadministrativestructureoftheCentralGovernmentfortheplanningofe-wastemanagementandsustainableenvironmentissues.

OnMarch22,2018,the rule was implemented by the ministry of environment and forest and climate change to manage E-waste in India.TheserulesarecalledE-WasteManagementAmendmentRules,2018toaddressthelacunasinformerlawsandworktowardssustainableenvironmentalgoals.

MajorhighlightsoftheE-Wasterules

a)Themanufactures,producers,importer,transporter, refurbisher,dismantler,recyclerareresponsibletopayfinancialpenaltiesasleviedbythe provisionoftheEnvironment(ProtectionAct).Moreover, thecollection,storage,transportation,segregation,refurbishment,dismantling,recycling, anddisposalofe-wasteshouldbebytheguidelines.

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b)TheCentralPollutionControlBoard(CPCB)cancon ductasurveyofelectricalandelectronicequipmentinth emarkettoassessthe situation forcomplianceofreductionofhazardoussubstancepro visionsandcostof this assessmentshallcome fromthegovernment,whichwasnotthecaseintheprevi ousamendment.Previously,thecostwascoming fromtheproducer.

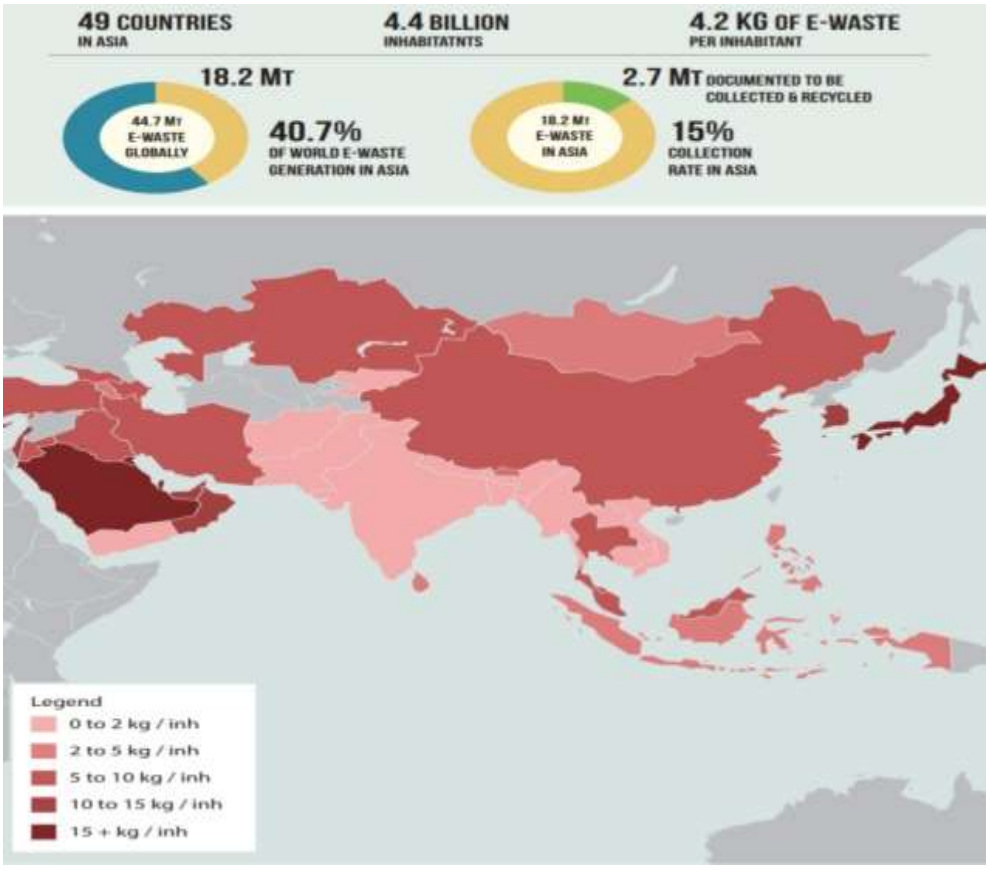

Fig:Asia'sOverview[41]

VI. ENVIRONMENTAL SOUND MANAGEMENT[31,32]

A.MeasuresweretakenbyIndustry

Manymanufacturers,corporations,individualandbul kconsumersshowedtheirattentiontowardsgeneration ,pilingupelectronicwasteanditsmismanagementinthe unorganizedsector.

MAIT(ManufacturersAssociationofITequipment)ha stakentheinitiativetopromotewasteelectricalandelect ronicequipment(WEEE)awarenessamongmanufact urersandcorporates.Asaresult,twopositivepointscam eout.

a)Ittriggeredmostofthecorporatesin Indiatoformulate ane-wastepolicy.

b)Theypromoteselfdisposalandcreateacleane-wastechannel.

Thewell-knownreputedcorporationslikeNOKIA,WIPRO,etc. havestartedtheirrecyclingplantinitiativestohelptowa rdssustainabledevelopment.TheGovernmentofIndia (MinistryofEnvironmentandForestandCentralpollut ioncontrolboard)hasdraftede-wastelegislationthathaspositionedthecorporationand manufacturerasamajorstockholderinhandlinge-waste.

NokiaActivities

Nokiabeganitse-wastemanagementcampaignin2008whene-wastedisposalwasgivenlittleattention.

Nokiasetupdropboxesacrossthecountryunderthe"take-backprogram"atNokiaCareCentresorPrioritydealers.

ApartfromthatNokiarunseveralcampaignsorinitiativesforenvironmentallysounde-wastemanagementareasfollows.

a)RecyclewithjoyatHMDMobileIndiaPrivateLimited. Toenablethis,NokiajoinedhandswithaCPCBauthorizedProducerResponsibilityOrganisation(PRO),KaroSambhavPrivateLimitedtoreachitsExtendedProducerResponsibilitycompliance.**EPR**isapolicyapp

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roachunderwhichproducersaregivensignificantresponsibility.TherearethreeprimaryobjectivesoftheEPRprinciple:

b)SchoolProgrammeAwareness-
Itisdesignedtocreateawarenessoncriticalenvironmentalissuesincludingwastefromelectronics.

C)BulkConsumerProgramme-
It'sobjectiveistoprovidearesponsiblee-wastemanagementsolutiontoabulkconsumerinIndia. Theprogramservesthee-wastemanagementneedsofoffices,governmentinstitutions,schools,universities,hospitals,hotels,retailers,etc.

d)WasteCollectorProgram-
Itfocusesonformalizingthewastepickersandaggregator.Bybeingapartoftheprogram,wastepickersandaggregatorsbecomeacollectionchannelofthePROandbringtransparencyintheirprocesses.
Thetotalquantityofmobilephonesandaccessoriescollectedfromthecampaignsinceitslaunchin2009is160tons.Thee-wastecollectionhasgrownfrom3tonsin2009to65tonsin2012.
AllNokiaphonesandaccessoriessoldworldwideareRoHS(ReductionofHazardousSubstance)compliantsince2006.

XiaomiActivities
XiaomijoinedhandswithaCPCBauthorizedProducer ResponsibilityOrganisation(PRO),KaroSambhavPrivateLimitedtofulfillitsExtendedProducerResponsibilitycompliance.AsapartoftheprogramKaroSambhavsettingupover1150e-wastecollectionpointsatallXiaomiMiHomesandMiauthorizedservicecentersinover500citiesacrossthecountry.Atcollectionpointsconsumerdrop-offphonesandotherXiaomiproductsandaccessoriesforresponsiblerecycling.
KaroSambhavthroughitsinitiativeshasengagedwithhundredsofbulkconsumersandthousandsofwastehandlerstoencourageresponsiblemanagementofe-waste.Itsschoolprogramhasreachedover1950schoolsandcommunicatedwithover8lakhsindividualsacrosthenation.Ithasalsosuccessfullycollectedandsentover4000MTsofe-wasteforresponsiblerecycling.

B.MorestepsIndustrycantake
a)R&Dinpromoting"BetterDesignforEnvironment" meansavoidinghazardoussubstancesinthemanufacturinganduseofenvironmentallymoderatematerialswouldhelp.Also“BetterDesignforRecycling”shouldbepromoted.
b)Moreattentionisrequiredtowardsimpactingfactors suchascostofrecycling,rateofobsolescence,decreasinglifespanofelectronicdevices,etc.

C.IndividualEffort[34]
Forhumanhealth"Preventionisbetterthancure"thisisalsoapplicabletoenvironmentalhealth.Itisbettertoreducewastethandisposingorrecyclingitafterthegeneration.Thegoalofenvironmentallysoundmanagementcan'tbeachievedwithoutindividualefforts.Therearecertainlysimpleandeasystepsforindividualsforachievingthegoalofenvironmentallysoundmanagementofe-waste.
Individualconsumerscanintheirwaydotheirbitforpromoting"Cleane-wastechannels‟,mitigatetheroleofthescrapyardsand" kabadiwalas"inthee-wastevaluechain, andpromoteawarenessamongstpeersaboutpropere-wastemanagementbythemosteffectiveway"Wordofmouth".
Itmaybedifficulttoavoidthetemptationofpurchasingthenew,fanciermobilephone,butitispossibletoincreasetheusageperiodofyourexistingone.Delayyourpurchasetothemaximum.Procrastinationforonceisgood.Donateyouroldelectronicstoindividualusersandnottoinstitutionsthatwillnotbeabletotracethedestinationofyouritem.
Collaborateandvalidatewhiledisposingofyouroldelectronicsnottosellitto"kabadiwalas‟.Insteadspreadtheawarenessamongstpeers,flatmates,neighbors,communitymembersaboutthedangersofsellingtheirobsoleteelectronicsto"kabadiwalas‟.
Apartfromthat,wehavetomaintainasimplifiedmodelofe-wastemanagementforthecirculareconomy.Thecircul

areconomysystemaimstokeepthevalueintheproductforaslongaspossibleandeliminatewaste.Inthisregard, countriesshouldcomeupwithlegislationtopromotecircularеconomymodelsinwhiche-wasteistreatedasaresourceratherthanawaste.

VII. CONCLUSION

E-wasteisoneofthebiggestproblemsintoday'sworld.E-wastecontainsavarietyofhazardoussubstances.Poor managementofe-wasteresultsincontaminationoftheenvironmentwhichultimatelyleadstohealthproblemsforalllivingbeings .E-wasteisalsonotgoodfortheeconomyifnotrecycledproperlybecausealargenumberofrawmaterialsareusedfortheproductionofe-products.Variousmetalslikeiron,aluminium,andplasticsarewasted.Somepreciousandrareelementsarealsousedine-productssuchasgold,silverandthesealsogetwasteddue topoorrecyclingtechniques.Theproperandappropriatee-wastemanagementpracticeswillhelpusinefficientsourcingandcollectionrightuptoextractionanddisposalofmaterialasaresultwastewillturnintolucrativeproductsandbusinessopportunities.Wecantakeanexamplefrom theJapanesee-wastemanagementpracticesinthiscontext.Manufacturersareadvisedtousesafermaterialsforproductsandenhancetheusefullifeoftheproductsalsotheyhavetotakeresponsibilityforimplementingtheguidelineswhicharesetupbythegovernment.Tocheckwhetherguidelinesareimplementedornotin IndiaCentralPollutionControlBoard(CPCB)mayconductarandomsamplingofelectricalandelectronicequipmentplacedinthemarkettomonitorandverifythecomplianceofthereductionofhazardoussubstanceprovisionsinregularintervals.RegularResearchandDevelopmentarerequiredforproduct developmenttoenhancereuseandrecycling.IntheIndiancontext,asuitablemechanismsmuchneededinwhichanunorganizedsectorconcentrateonthecollection,dismantling,andsegregationwhereas,themetalextraction,recycling,anddisposalcouldbedonebytheorganized sector.

Thereshouldbeawarenessprogramstomakecitizensawareoftheharmsofe-waste.Consumersshouldalsounderstandtheirresponsibility,andshouldonlygivetheirwastestoauthorizedwastecollectioncenters.

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