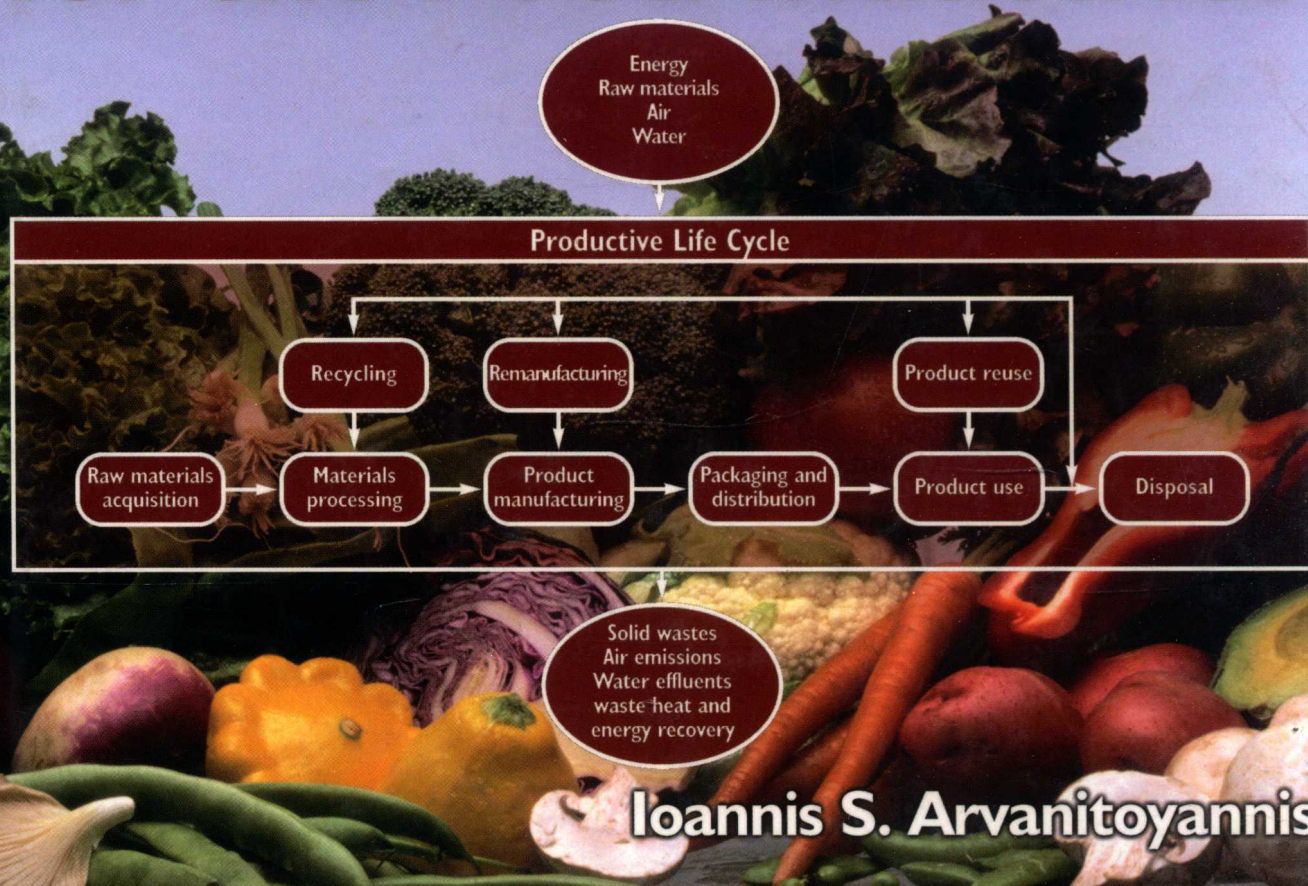




Waste Management for the Food Industries



Ioannis S. Arvanitoyannis

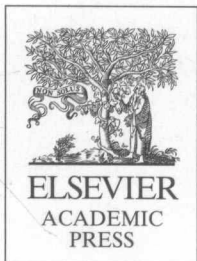


Waste Management for the Food Industries

Authored by

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Waste Management for the Food Industries

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A complete list of books in this series appears at the end of this volume.

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*To my wife for her unfailing support and affection
throughout the long preparation of this book*

*To my three children (Iason, Artemis-Eleni, Nefeli-Kallisti)
for their warm-hearted smiles*

I.S. ARVANITOYANNIS

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Preface

The continuously increasing human population (more than 7 billion) has resulted in a huge demand for processed and packaged food. Food processing and food packaging have led to a substantial depletion of non-renewable resources. In fact, large amounts of water, air, electricity and fuel are consumed on a daily basis for food processing, transportation and preservation purposes. Apart from this, however, the lack of implementing a life cycle analysis (LCA), where all by-products or sub-products of food processing could effectively enter the Krebs cycle, is an omnipresent reality. All these incidents have had a very ominous effect on the quality of the environment, which has continued to deteriorate very rapidly over the last 20–30 years. Despite the agreements stipulated in the Montreal and Kyoto protocols and what was voted within the frame of the Green and White Bible, the truth is that the environment shows a rapidly declining trend.

Although the food industry is not one of the most heavily polluting, it contributes to a considerable extent to this already acute problem. Promising solutions consist of opting for 'green' processing technologies (implying zero/low consumption of non-renewable resources) in conjunction with usage of by-products and/or waste materials. The latter can prove to be very useful since they contain compounds with therapeutic actions (i.e. antioxidants in olive oil extraction, aromas in orange juice extraction). Another very important issue is food packaging materials which account for almost 5% of the total weight (15% of the total volume) of waste materials. Most of it is manufactured out of polymeric material (plastic). Recycling is a promising solution to this problem, but composting, landfilling and, occasionally, incineration are the most widely employed processes. Although these processes are of low cost, they do contribute heavily to high environmental pollution as well.

This book consists of 15 chapters, divided into the following parts:

- Part 1: Environmental management systems: applications and potential
- Part 2: Environmental legislation
- Part 3: Waste treatment methodologies
- Part 4: Waste treatment methodologies of foods of plant origin
- Part 5: Waste treatment methodologies of foods of animal origin
- Part 6: Food packaging waste treatment.

In Part 1, a presentation of the current environmental management systems' (EMS) situation is attempted, a comparison of the various EMS is made and emphasis is put on life cycle analysis because the latter represents one of the most promising and reliable approaches in terms of assessing the environmental impact of the employed processes. In Part 2, the main Directives of the EU and Acts of the USA and Canada are given in the form of comprehensive tables accompanied by the main points and a text summary. It is evident that EU legislation is much more flexible and changeable (many amendments in a short period) than the respective USA and Canadian legislation. Part 3 (Chapter 6) describes the various waste treatment methodologies such as drying, landfilling, thermal processes (incineration, pyrolysis, combustion), composting, anaerobic digestion, bioremediation, ozonation, electrolysis, evaporation, coagulation/precipitation. Informative tables are given where the method characteristics, advantages and disadvantages are included. Though a comprehensive chapter, it could have been much longer in view of the great number of waste treatment methods employed. Part 4 includes waste treatment methods of selected foods of plant origin (grape/wine, olive/olive oil, orange/lemon/juice, sugarcane/sugar, almond, wheat, maize, barley, rye) and the potential uses of treated waste. Part 5 follows the same line as Part 4 but is focused on waste treatment methods of foods of animal origin (meat, dairy and fish) and the potential use of their treated waste. Finally, Part 6 is a very comprehensive chapter covering all the packaging materials for food applications such as plastics, glass, carton, paper, metal, aluminum and combinations.

The aim of this book is to provide both general and practical knowledge and information about the current and potential waste treatment methods. It also contains extensive and thorough information related to the uses/applications of the ensuing treated waste. The large amount of updated information (many informative tables for waste treatment methodologies, treated waste uses and more than 3000 references) in this book will make it very useful to industrialists, academics and researchers.

Ioannis S. Arvanitoyannis
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Abbreviations

AA	Adipic acid
ABE	Activated Bleaching Earth
ADP	Abiotic resources Depletion Potential
AFB	Anaerobic Fluidized Bed
AFBR	Anaerobic Fluidized Bed Reactors
AFFR	Anaerobic Fixed Film Reactor
AGM	Atmospheric greenhouse model
AHF	Anaerobic hybrid filter
ALRP	Aluminum recycling by-product
ANOVA	Analysis of variance
AP	Acidification Potential
API	Air Pollution Index
API	American Petroleum Institute
APME	Association of Polymer Manufacturers in Europe
ASBR	Anaerobic Sequencing Batch Reactors
AX	Arabinoxylan
BAPEDAL	Indonesia Environmental Impact Management Agency
BAT	Best available techniques
BFBC	Fluidized bed combustion
BHA	Butylated-hydroxyanisole
BHT	Butylated-hydroxytoluene
bio-CNG	bio-compressed natural gas
BMP	Biochemical Methane Potential
BNR	Biological Nutrient Removal
BOD	Biological Oxygen Demand
BPF	By-product feedstuffs
BSE	Bovine Spongiform Encephalopathy
BSS	Biofilm Support System
BW	Black Water
CAA	Clean Air Act
CAFOs	Confined animal feeding operations

CAP	Common Agricultural Policy
CBA	Cost-benefit analysis
CBC	Circulating bed combustor
CBOD	Carbonaceous Biochemical Oxygen Demand
CCGT	Combined-cycle gas turbine
CCP	Critical Control Points
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERES	Crop estimation through resource and environment synthesis
CFB	Circulating fluidised bed
CFD	Computational fluid dynamics
CFP	Common Fisheries Policy
CFR	Code of Federal Regulations
CHP	Combined heat and power
CIP	Cleaning-in-place
CM	Chicken manure
CMA	Chemical Manufacturers Association
CMRs	Carcinogens, mutagens and reproductive toxins
CNG	Compressed Natural Gas
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
COPD	Chronic Obstructive Pulmonary Disease
COPE	Compensation for Oil Pollution in Europe
CP	Crude protein
CPB	Corrugated paperboard
CPM	Chemical Pest Management
CS	Cattle slurry
CST	Critical Surface Time
CSTR	Continuous Stirred Tanks Reactors
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DAA	Dodecylamine acetate
DAF	Dissolved Air Flotation
DBSNa	Dodecylbenzenesulfonic acid-sodium salt detergent
DCDS	Digested Cow Dung Slurry
DCOD	Dissolved Chemical Oxygen Demand
DDGS	Distiller's Dried Grains with Solubles
DDT	Dichloro- Diphenyl- Trichloroethane
DEG	Diethylene glycol
DF	Diafiltration
DH	Degrees of hydrolysis
DHA	Docosahexanoic acid
DIS	Draft International Standard
DM	Dry matter
DO	Dissolved Oxygen

DOE	Department of Energy
DPWW	Dairy Parlour Wastewater
DSFF	Downflow Stationary Fixed Film
DSN	Data Source Name
DTPA	Diethylene triamine pentaacetic acid
EA	Environmental Auditing
EAA	Essential amino acids
EAA	Ethylene acrylic acid
EAPS	Environmental aspects of product standards
EC	Electric conductivity
EC	European Commission
ECCP	European Climate Change Programme
ECE	Economic Commission for Europe
ED	Electrodialysis
EDTA	Ethylenediamine tetraacetic acid
EDX	Energy dispersive X-rays
EEA	European Environment Agency
EEC	European Economic Community
EEl	Energy Efficiency Indicator
EES	Environmental Effects Statement
EFTA	European Free Trade area
EG	Exhausted grape marc
EIA	Environmental Impact Assessment
EQ	Environmental Impact Quotient
EIS	Environmental Impact Statement
EL	Environmental Labelling
ELV	Environmental Load Value
EM	Environmental Management
EMA	Environmental Management Act
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
EOPC	Extracted olive press cake
EP	Environmental Performance
EP	Eutrophication Potential
EPA	Eicosapentanoic acid
EPA	Environmental Protection Act
EPA	Environmental Protection Agency
EPE	Environmental Performance Evaluation
EPR	Extended Producer Responsibility
EPR	Electron Paramagnetic Resonance
EPS	Expanded polystyrene
EQOs	Environmental Quality Objectives
EQSs	Environmental Quality Standards
ERenEf	Energy renewability efficiency

ERS	Economic Research Service
ES	Environmental Statement
ESA	Endangered Species Act
ESH	Environment, safety and health
EPS	Expanded polystyrene
ETI	Environmental Technology Initiative
ETS	Ecological Treatment System
EU	European Union
EVA	Ethylene-vinyl acetate
FA	Fatty acid
FAME	Fatty acid methyl ester
FBC	Fluidised Bed Combustor
FC	Faecal Coliforms
FE	Feed efficiency
FFA	Free Fatty Acids
FFCA	Federal Facility Compliance Act
FGDP	Flue gas desulfurization by-product
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
FIFO	First-in, first-out
FP	Flash pyrolysis
FPH	Fish Protein Hydrolysates
FR	Federal Register
FVFMSW	Fruit and vegetable fraction of municipal solid wastes
FVSW	Fruits and vegetable solid wastes
FVW	Fruit and vegetable wastes
FW	Fish waste
FW	Freshwater fish
GATT	General Agreement on Tariffs and Trade
GC	Gas chromatographer
GHG	Greenhouse gas
GLC	Gas-liquid chromatography
GLP	Good Laboratory Practice
GM	Grape marc
GMOs	Genetically Modified Organisms
GS	Gas separation
GS	Grape stalk
GSE	Grape seed extracts
GSP	Generalised system of preferences
GSPC	Grape seed proanthocyanidins
GVM	Gesellschaft für Verpackungsmarktforschung
GWC	Green Waste Composts
GWP	Global Warming Potential
HACCP	Hazard Analysis Critical Control Points
HAPs	Hazardous Air Pollutants

HC	Hydrocarbon
HCFCs	Hydrochlorofluorocarbons
HD	Hexane diamine
HDL	High-density lipoproteins
HDPE	High density polyethylene
HFCs	Hydrofluorocarbons
HHV	Higher Heating Value
HM	Heavy metal
HMTA	Hazardous Materials Transportation Act
HMWPP	High molecular weight polypropylene
HPAEC-PAD	High-pressure anion-exchange chromatography pulsed amperometric detection
HRT	Hydraulic Retention Times
HUFA	Highly Unsaturated Fatty Acids
IC	Ion chromatography
ICZM	Integrated Coastal Zone Management
IFGT	Indirectly fired gas turbine
IGCC	Integrated Gasification Combined Cycle
IISD	International Institute for Sustainable Development
IMO	International Maritime Organisation
IMPEL	Implementation and Enforcement of Environmental Law
IMS	Intelligent Motion Systems
IOEA	Input-output energy analysis
IPA	Isopropyl alcohol
IPCC	Intergovernmental Panel on Climate Change
IPD	Isophorone diamine
IPM	Integrated Pest Management
IPPC	Integrated Pollution Prevention and Control
IRMS	Isotope ratio mass spectrometry
IRR	Internal Rate of Return
ISO	International Standardization Organization
LAR	Lactate Aerobic
LCA	Life Cycle Analysis
LCFA	Long-chain fatty acid
LCIA	Life Cycle Impact Assessment
LCS	Ligno-cellulosic substrate
LDL	Low-density lipoproteins
LDPE	Low density polyethylene
LEFR	Laminar entrained flow react
LHV	Lower heating value
LiP	Lignin peroxidase
LLA	L-lactide

LLDPE	Linear low-density polyethylene
LLRPA	Low Level Radioactive Policy Act
LPG	Liquefied petroleum gas
LR	Loading rate
MACT	Maximum Achievable Control Technology
MAFF	Ministry of Agriculture, Fisheries and Food
MAP	Manure Action Plan
MB	Mass Balance
MB	Methylene blue
MB	Moving bio-film
MBM	Meat and bone meal
MBR	Membrane bioreactor
MDI	Methylenebis (phenyl isocyanate)
MEE	Metabolizable energy efficiency
MEET	Multistaged Enthalpy Extraction Technology
MF	Microfiltration
MFD	Material Flow Diagram
MI	Market-incentive
MIR	Mid Infrared
MnP	Manganese-dependent peroxidase
MP	Mandarin peels
MPRSA	Marine Protection, Research and Sanctuaries Act
MRL	Maximum Residue Limit
MS	Mass spectrometry
MSW	Municipal solid waste
MUDS	Marine Underwater Depuration System
MW	Meat waste
NAA	Nonattainment area
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NCP	National Contingency Plan
NEC	No effect concentration
NEPA	National Environmental Policy Act
NF	Nanofiltration
NFE	Nitrogen free extracts
NGCC	Natural Gas Fired Combined Cycle
NGOs	Non-governmental organisations
NIR	Near infrared
NMR	Nuclear magnetic resonance
NOEC	No-observed-effect-concentration
NPDES	National Pollutant Discharge Elimination System
NPN	Non-protein-nitrogen
NPV	Net Present Value

NSC	Non-selected compost
NTA	Nitrilotriacetic acid
OAERRE	Oceanographic Applications to Eutrophication in Regions of Restricted Exchange
OandG	Oil and Grease
OBW	Organic Biological Wastes
ODA	Octadecanedioic acid
ODP	Ozone Depletion Potential
OECD	Organisation of Economic Co-operation and Development
OFMSW	Organic fraction of municipal solid wastes
OHS	Occupational Health and Safety
OL	Olive leaves
OM	Oversize materials
OMSR	Olive mill solid residue
OMSW	Olive mill solid wastes
OMW	Olive mill wastewaters
OOC	Olive oil cake
OP	Orthophosphate
OPA	Oil Pollution Act
OPC	Olive press cake
ORLs	Organic loading rate
OSHA	Occupational Safety and Health Administration
OTB	Olive tree branches
OTL	Olive tree leaves
PAC	Powdered Activated Charcoal
PACM	(Para-aminocyclohexyl)-methane
PAHs	Polynuclear aromatic hydrocarbons
PBM	Population Balance Model
PBTs	Persistent, bioaccumulative and toxic substances
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo dioxins
PCDF	Polychlorinated dibenzofurans
PCL	Poly (ϵ -caprolactone)
PCSD	President's Council on Sustainable Development
PCTs	Polychlorinated terphenyls
PE	Person equivalents
PE	Polyethylene
PES	Polyethersulfone
PET	Polyethylene terephthalate
PFP	Passion fruit peels
PF	Pulverized Fuel
PFCs	Perfluorocarbons
PFD	Process Flow Diagram
Ph	Phenol

PIC	Prior Informed Consent
PM	Particulate matter
PMMA	Poly(methyl methacrylate)
PO	Propylene oxide
POFP	Photo-Oxidants Formation Potential
POME	Palm oil mill effluents
POPs	Persistent Organic Pollutants
POTWs	Publicly-owned treatment works
PP	Polypropylene
PPA	Pollution Prevention Act
ppm	Parts per million
PS	Polystyrene
PTA	Purified terephthalic acid
PV	Pervaporation
PVA	Poly(vinyl alcohol)
PVC	Polyvinyl chloride
PY	Pyrolysis
QMS	Quality Management Systems
R	Recovery
RCRA	Resource Conservation and Recovery Act
RED	Reregistration Eligibility Decision
REACH	Registration, evaluation, authorisation and restriction of chemicals
RfD	Reference Dose
RO	Reverse Osmosis
RS	Reducing sugars
SAGE	Strategic Advisory Group for the Environment
SARA	Superfund Amendments and Reauthorization Act
SBR	Sequencing batch reactor
SCCP	Scientific Committee on Consumer Products
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
SCHER	Scientific Committee on Health and Environmental Risks
SCLCA	Soil Conservation and Land Care Act
SCOD	Soluble Chemical Oxygen Demand
SCP	Service Control Point
SDCP	Solar dried citrus pulp
SDM	Self Diagnosis Method
SDWA	Safe Drinking Water Act
SEM	Scanning electron microscopy
SETAC	Society for Environmental Toxicology and Chemistry
SFE	Supercritical fluid extraction
SH	Sulphydryl