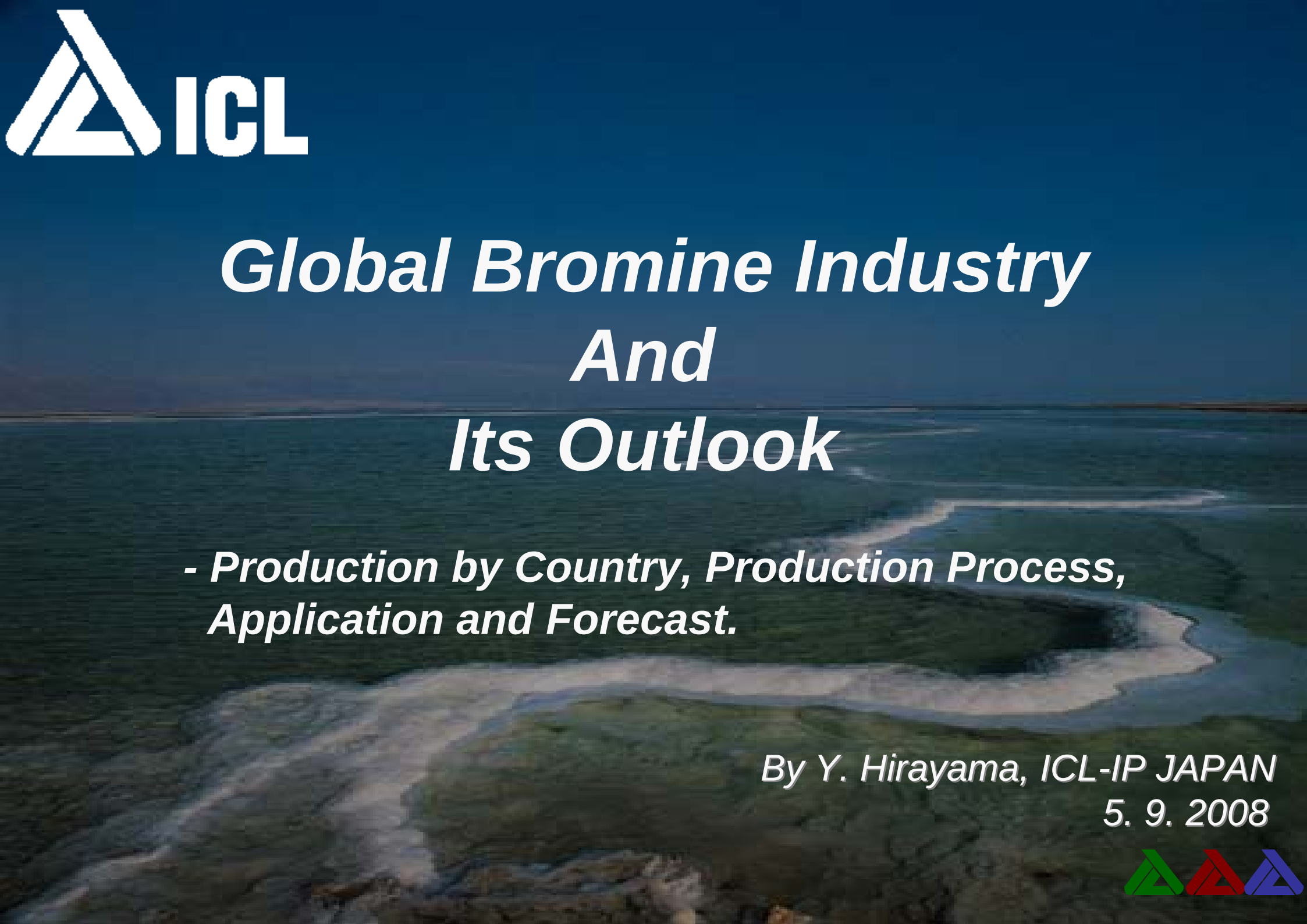

Global Bromine Industry And Its Outlook

- Production by Country, Production Process, Application and Forecast.

By Y. Hirayama, ICL-IP JAPAN

5. 9. 2008

Content

1. Bromine Production by Country
2. Concentration by Source
3. Bromine Production Capacity by Region
4. Bromine Production Flow
5. Bromine Compounds Market by Major Application
6. Bromine Flame Retardants
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Bromine: the essentials

Brief description: bromine is the only liquid nonmetallic element. It is a member of the halogen group. It is a heavy, volatile, mobile, dangerous reddish-brown liquid. The red vapor has a strong unpleasant odor and the vapor irritates the eyes and throat. It is a bleaching. When spilled on the skin it produces painful sores. It is a serious health hazard, and maximum safety precautions should be taken when handling it.

Table: basic information about and classifications of bromine.

Name: Bromine

Symbol: Br

Atomic number: 35

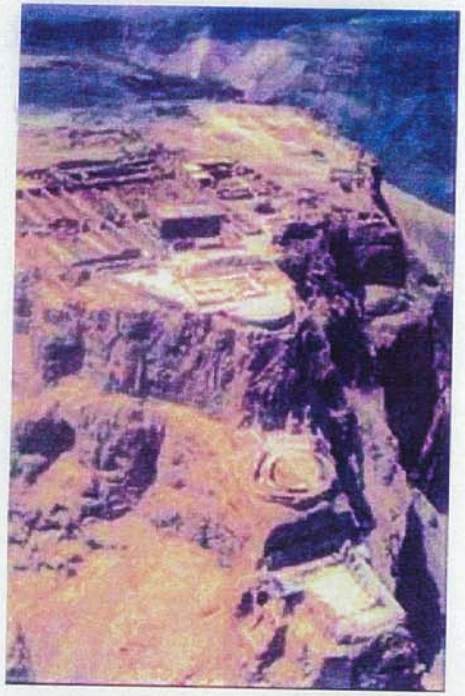
Atomic weight: 79.904 (1)

Standard state: liquid at 298K

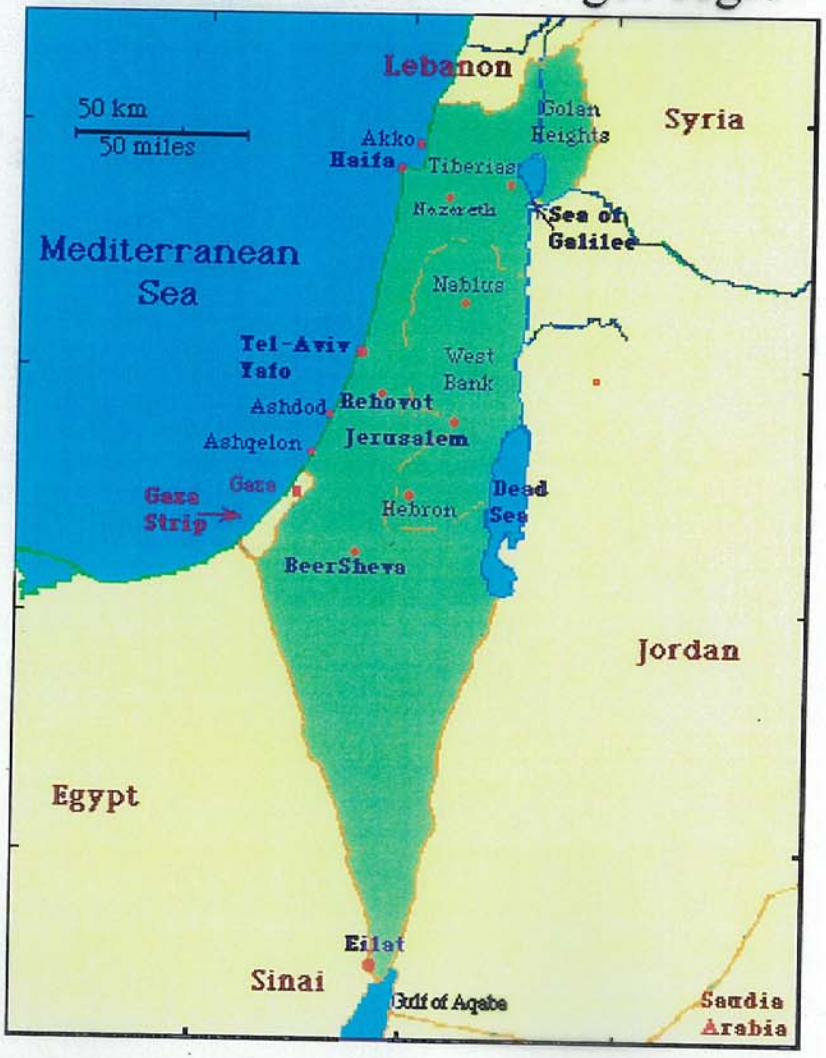
CAS Registry ID: 7726-95-6

Isolation

- Isolation
- Isolation: bromine is available commercially so it is not normally necessary to make it in the laboratory. Bromine also occurs in seawater as the sodium salt but in much smaller quantities than chloride. It is recovered commercially through the treatment of seawater with chlorine gas and flushing through with air. In this treatment, bromide is oxidized to bromine by the chlorine gas. The principle of oxidation of bromide to bromine is shown by the addition of a little chlorine water to aqueous solutions of bromide. These become brown as elemental bromine forms.
- $2Br^- + Cl_2 \rightarrow 2Cl^- + Br_2$
- Small amounts of bromine can also be made through the reaction of solid sodium bromide, NaBr, with concentrated sulphuric acid, H_2SO_4. The first stage is formation of HBr, which is a gas, but under the reaction conditions some of the HBr is oxidized by further H_2SO_4 to form bromine and sulphur dioxide. This reaction does not work with the corresponding chlorides and fluorides.
- $NaBr\ (s) + H_2SO_4\ (l) \rightarrow HBr\ (g) + NaHSO_4\ (s)$
- $2HBr\ (g) + H_2SO_4\ (l) \rightarrow Br_2\ (g) + SO_2\ (g) + 2H_2O\ (l)$

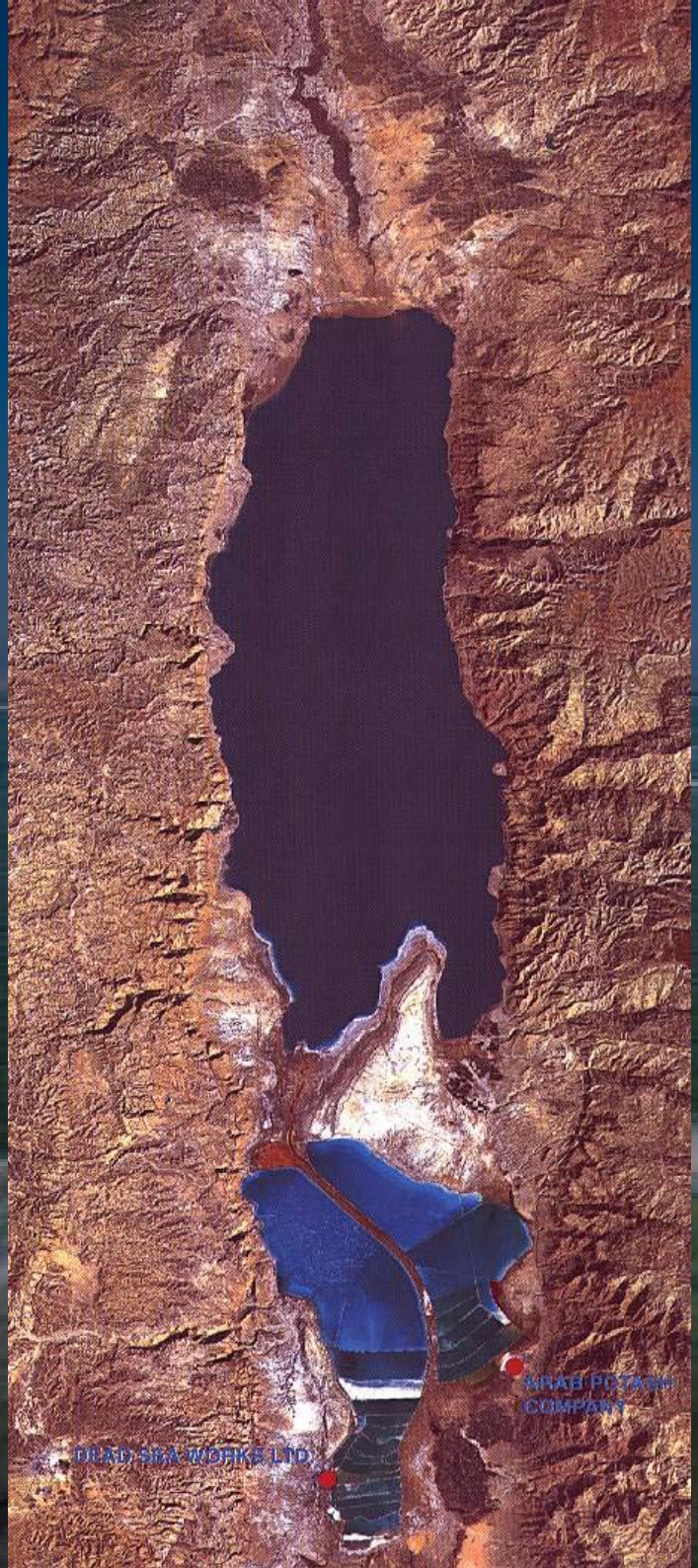


Israel: views from the Negev region



May 1999

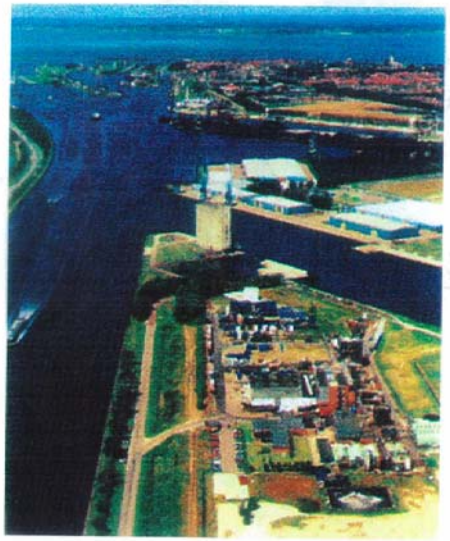
The Dead Sea



Dead Sea Solar evaporation ponds

Raw material harvester

DSBG



Bromine Compounds Plant - Netherlands

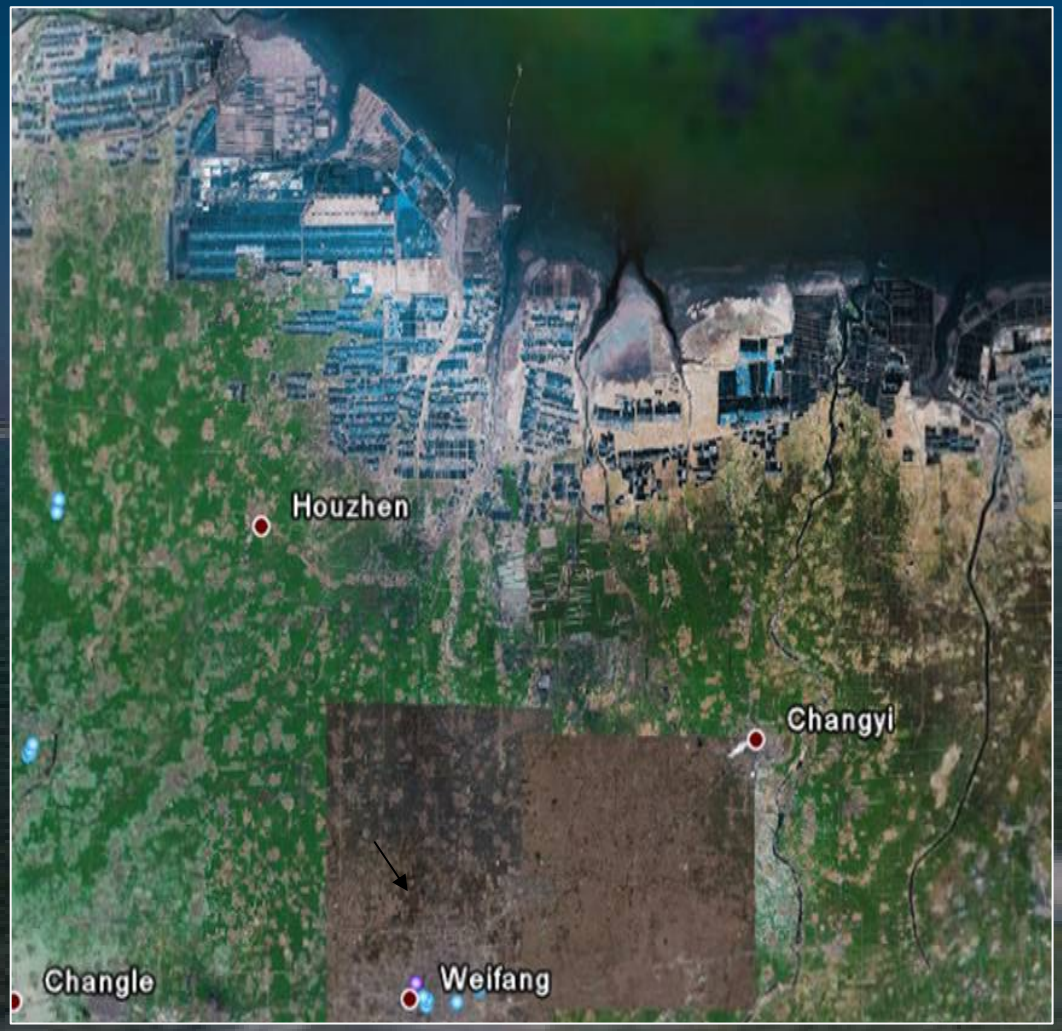
Bromine/Chlorine Plant - Israel

An Introductory Presentation

23/11/00

BROMINE ISOTANKS ROUNDTRIP IMPROVEMENT

Where Has the Market Share Gone? To China…



Aerial photo of Bromine production area in Shandong

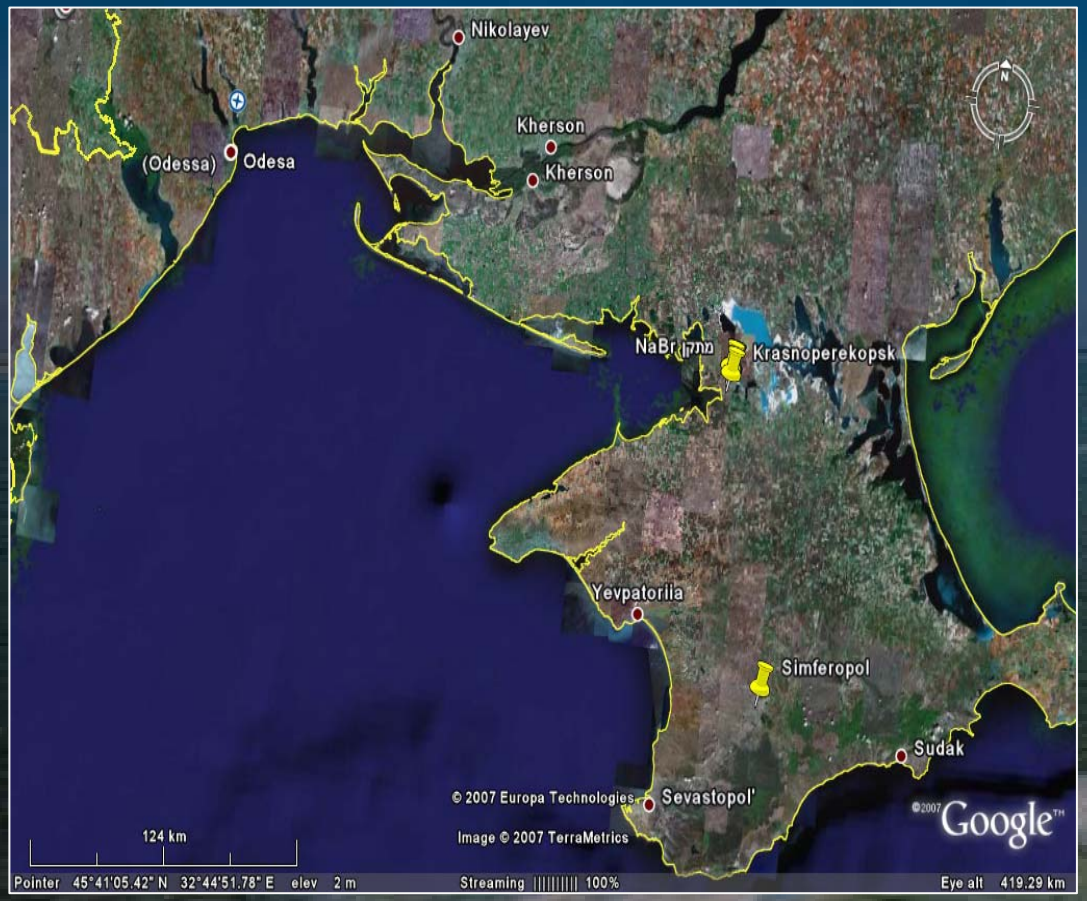
Chinese Bromine production and packing facility

Bromine Production - India

Indian evaporation pond

Indian plant

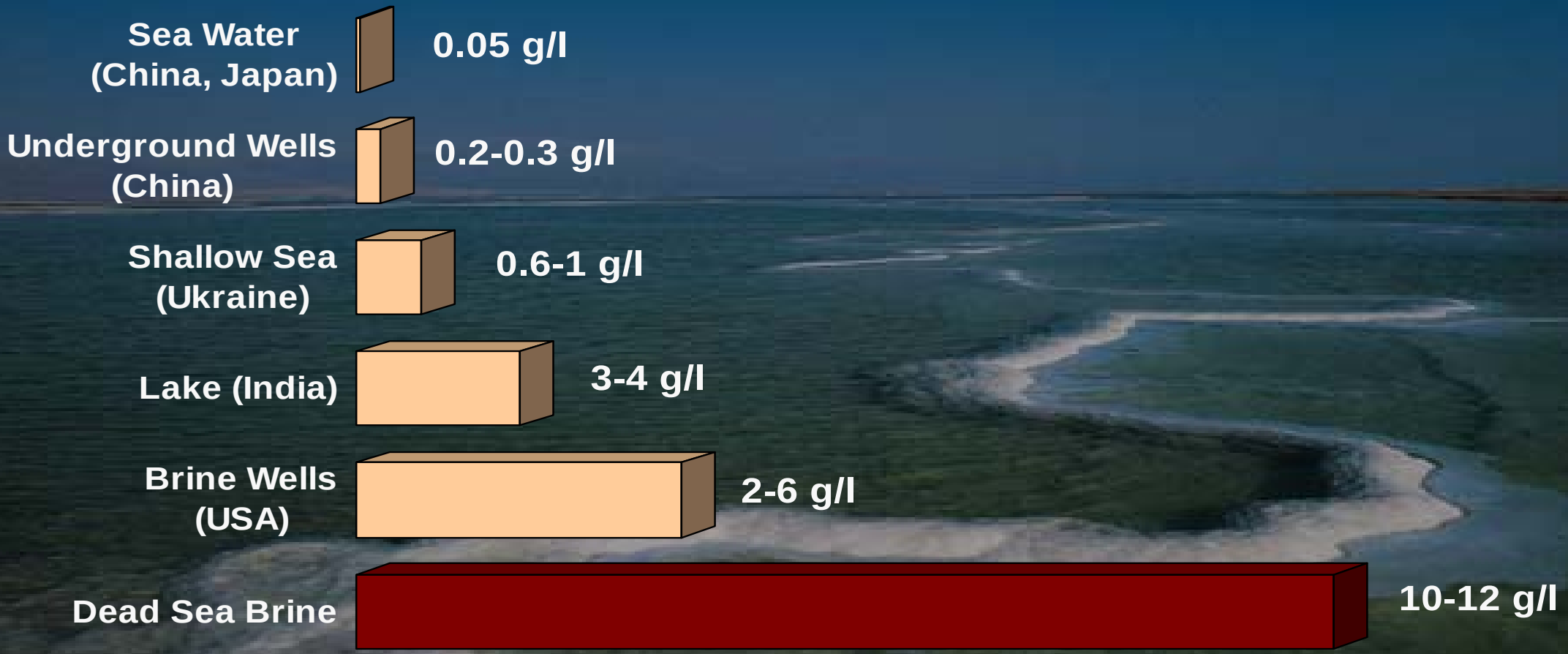
Emerging Ukraine ???



Satellite photo of relevant Ukrainian regions

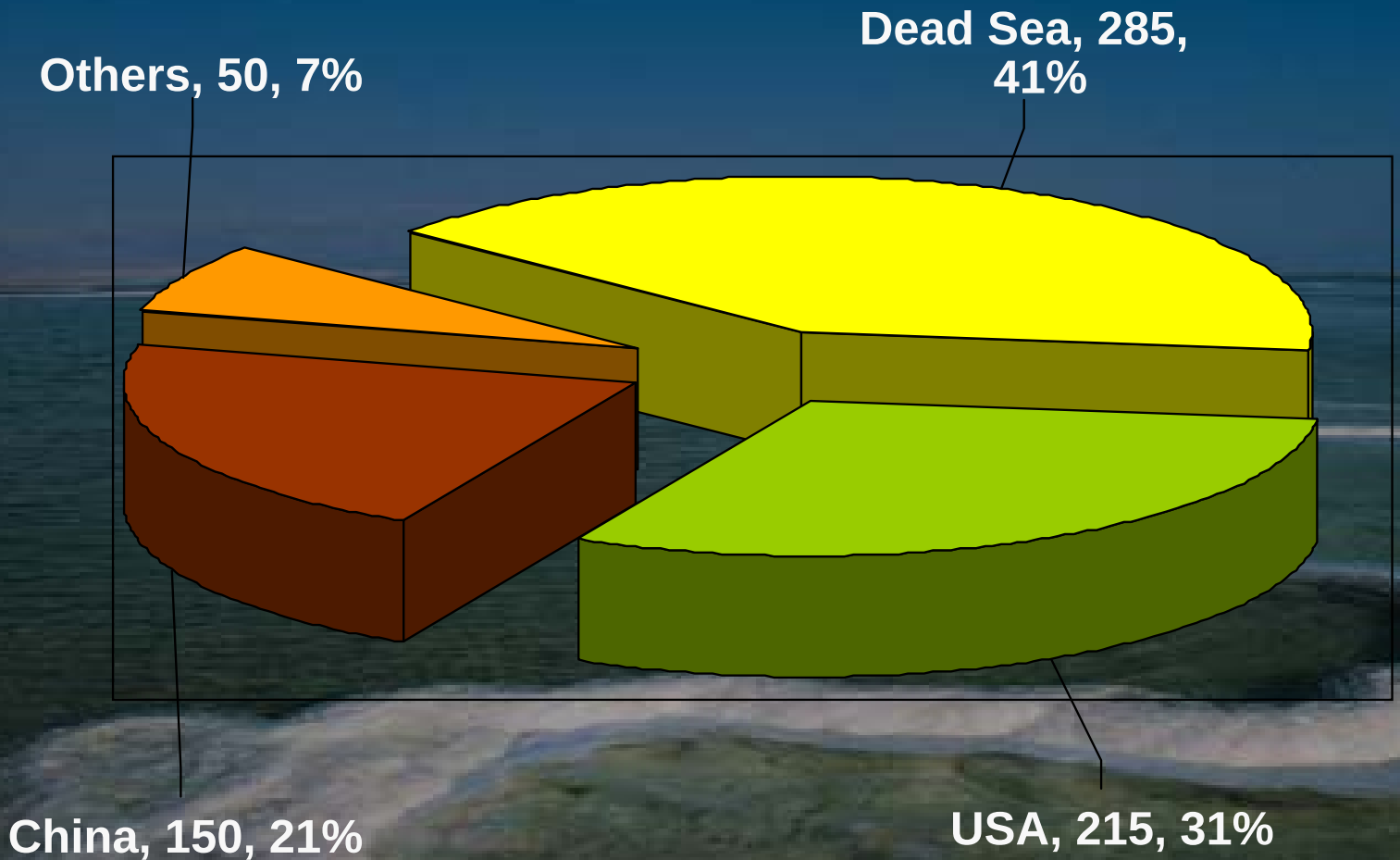
Ukrainian bromine plant

Bromine Concentration by Source

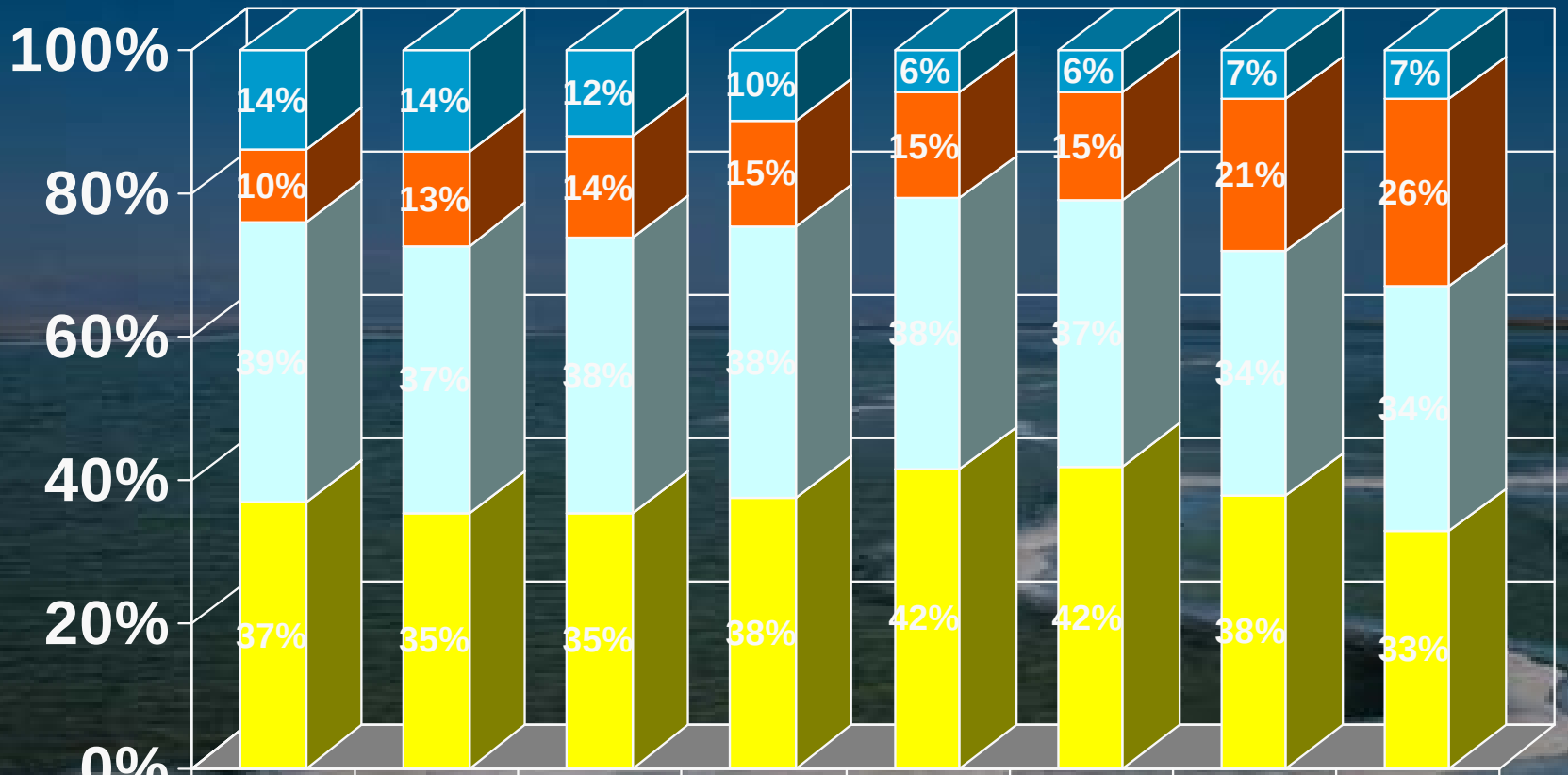


Source: ICL estimates

Global Bromine Production Capacity- by Region (700 KMT)

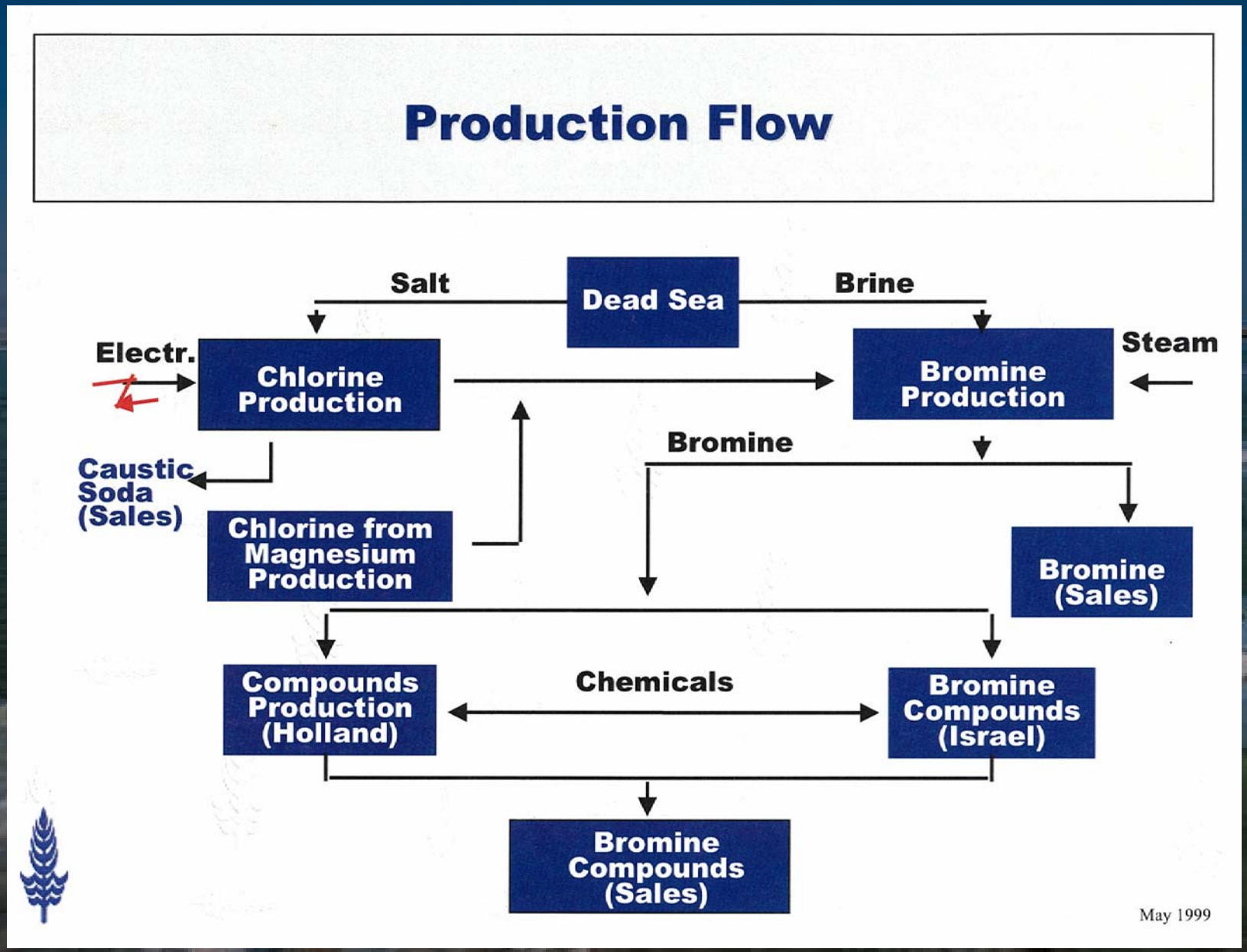


Bromine Production (by Region - % of total production)

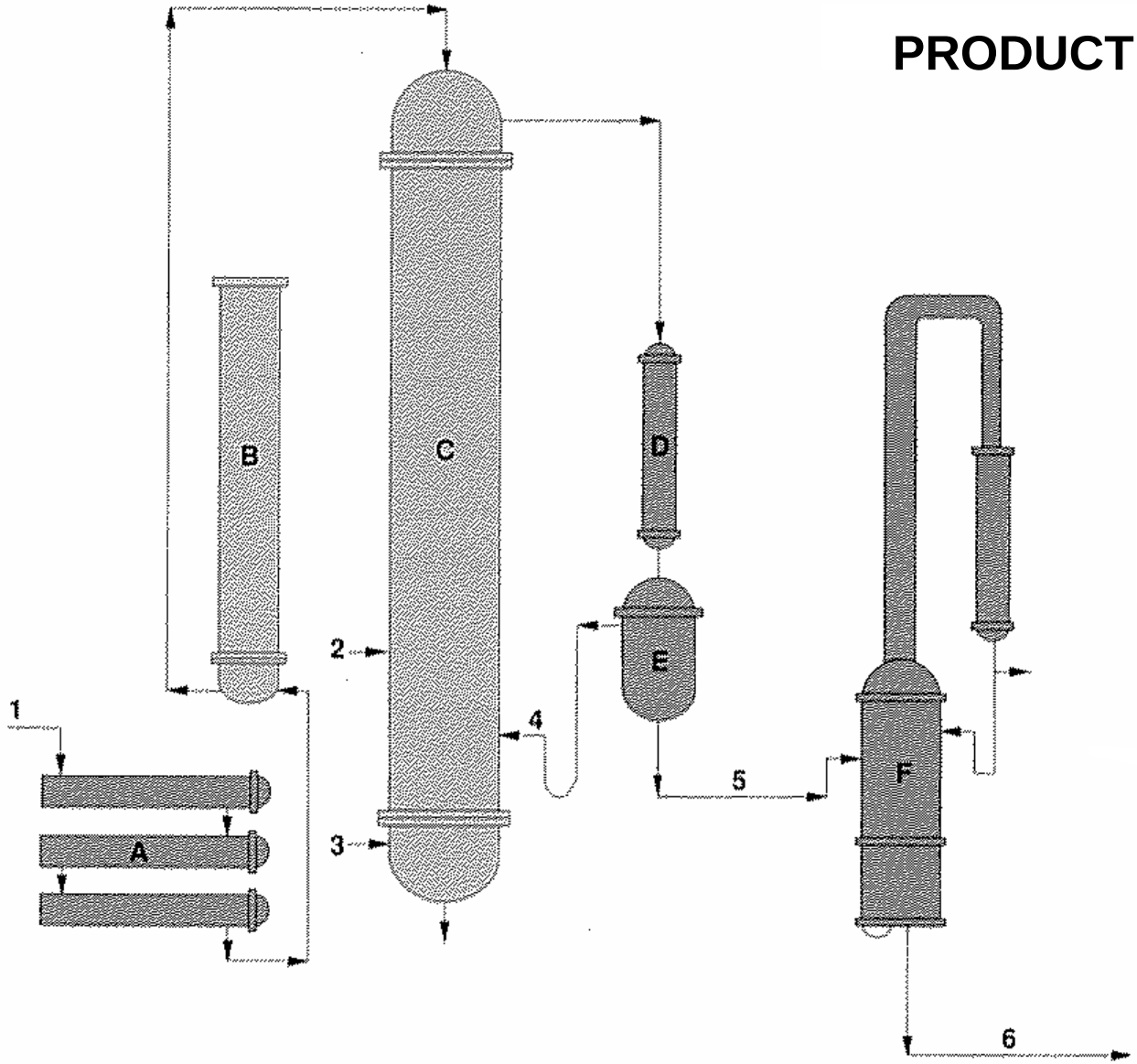


	2000	2001	2002	2003	2004	2005	2006	2007
ROW	14%	14%	12%	10%	6%	6%	7%	7%
China	10%	13%	14%	15%	15%	15%	21%	26%
USA	39%	37%	38%	38%	38%	37%	34%	34%
Dead Sea	37%	35%	35%	38%	42%	42%	38%	33%

Production Flow in ICL-IP

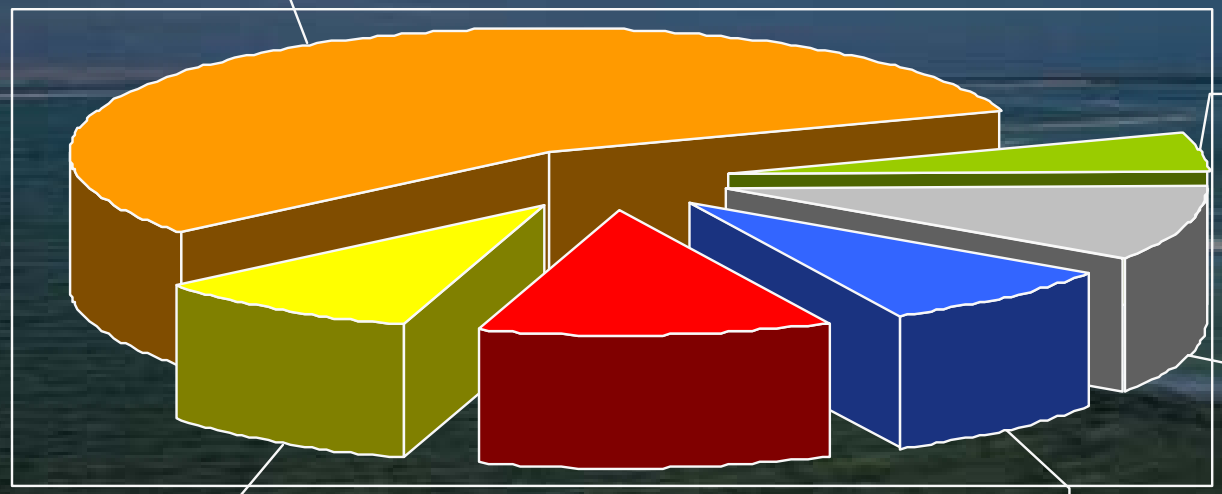


PRODUCTION FLOW CHART

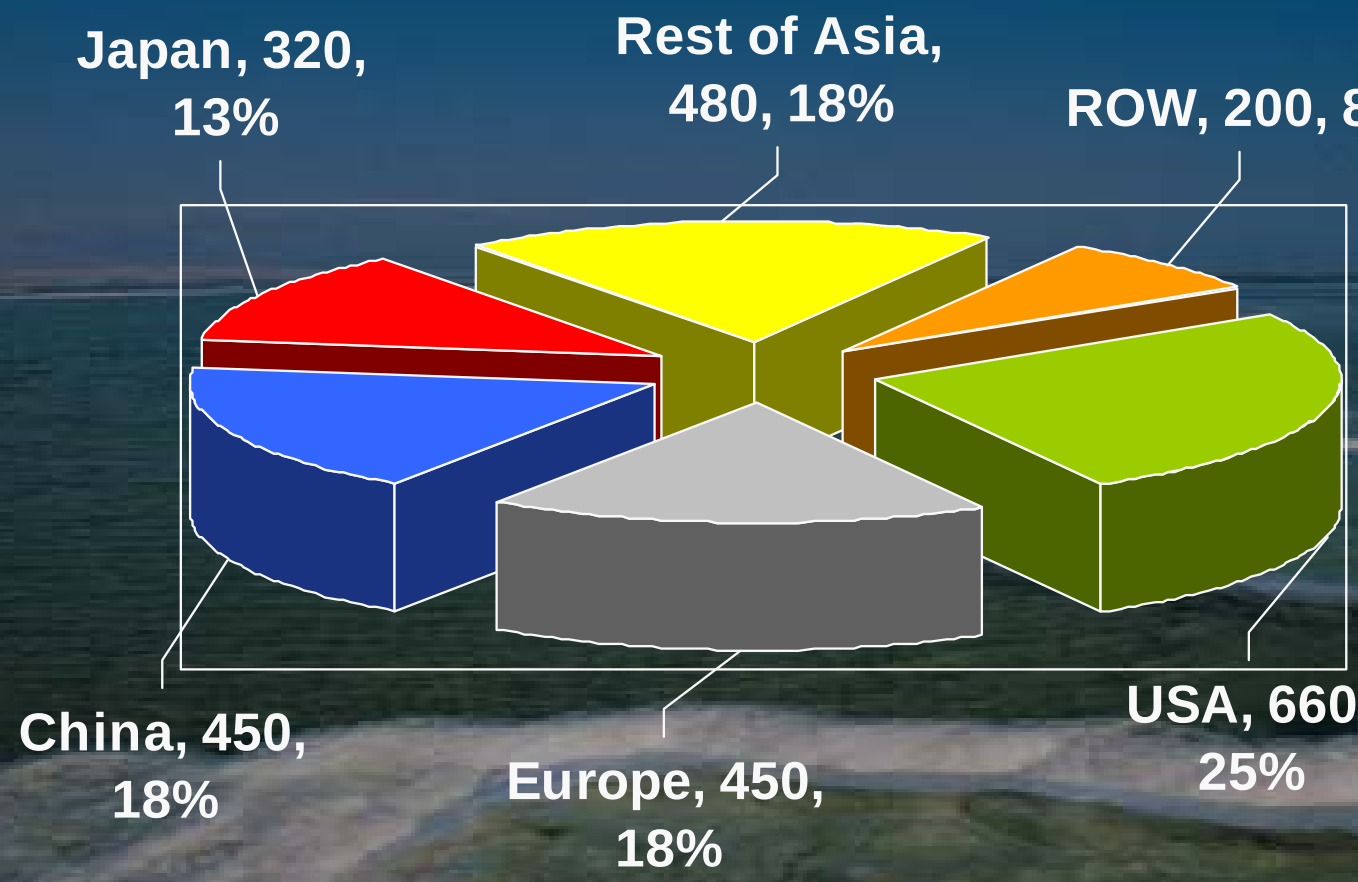


LEGEND: Bromide-enriched Dead Sea brine (1), heated by preheaters (A) and heat-exchanger (B), flows into a reaction column (C) in which the introduced chlorine (2) liberated elemental bromine. Steam (3) is used to strip the bromine out of the reaction column and into a condenser (D). from which the bromine flows into a phase separator (E). The bromine-saturated water (4) is returned to the reaction column, while the bromine (5) passes, first, to a distillation column (F). After cooling, the purified liquid bromine flows to storage (6),

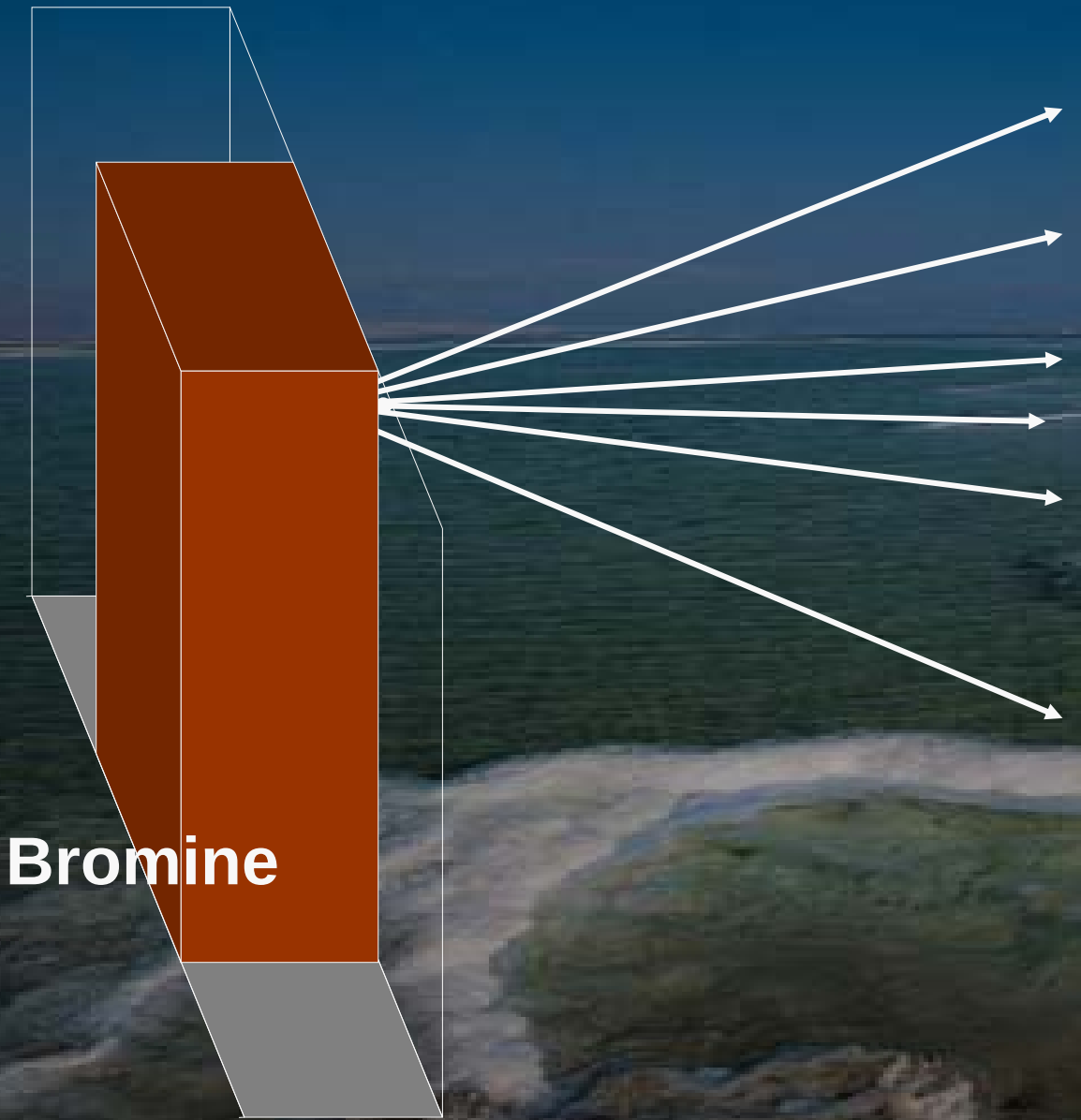
Global Bromine Compounds Market- by Major Application (Total in 2007- $2.5 BN)

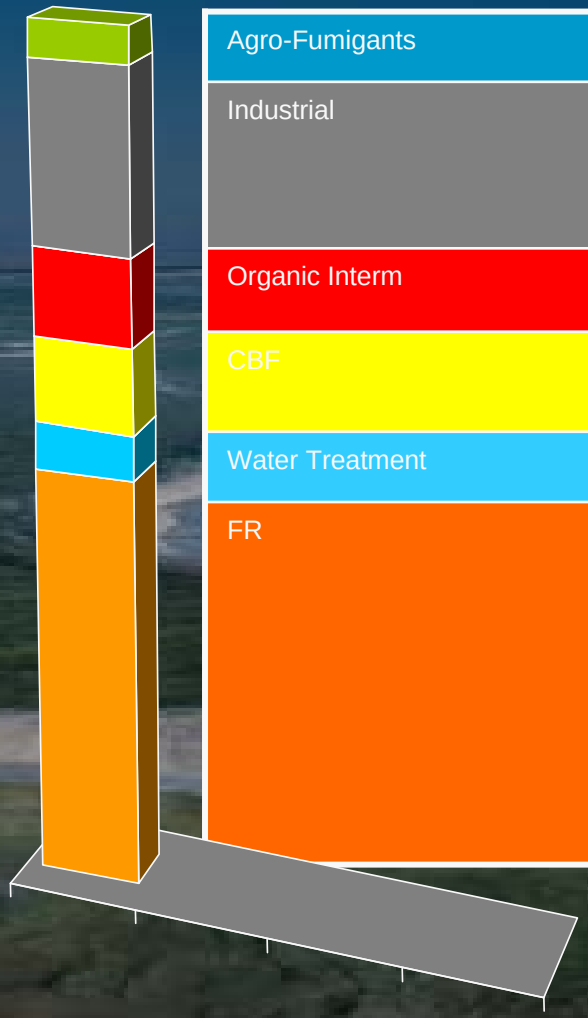


Bromine Compounds Consumption – By Region ($2.5 BN - 2007)



Demand by Application (In terms of Bromine – 575 KMT in 2007)





Agro-Fumigants	25	4%
Industrial	105	18%
Organic Interm	63	11%
CBF	67	12%
Water Treatment	32	5%
FR	283	49%

Use of Bromine Compounds

- Flame retardants
- Agrochemicals
- Water treatment chemicals
- Pharmaceuticals and cosmetics
- Lead scavenger in anti-knock fuels
- Oilfield completion fluids
- Photographic chemicals
- Desiccants for cooling systems
- Bleaching and oxidizing chemicals
- Dyestuffs
- Monomers for specialty polymers
- Precision cleaning

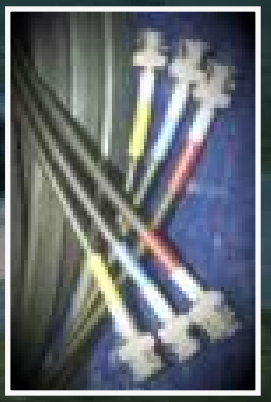
Electrical and electronic continues to improve the quality of our lives







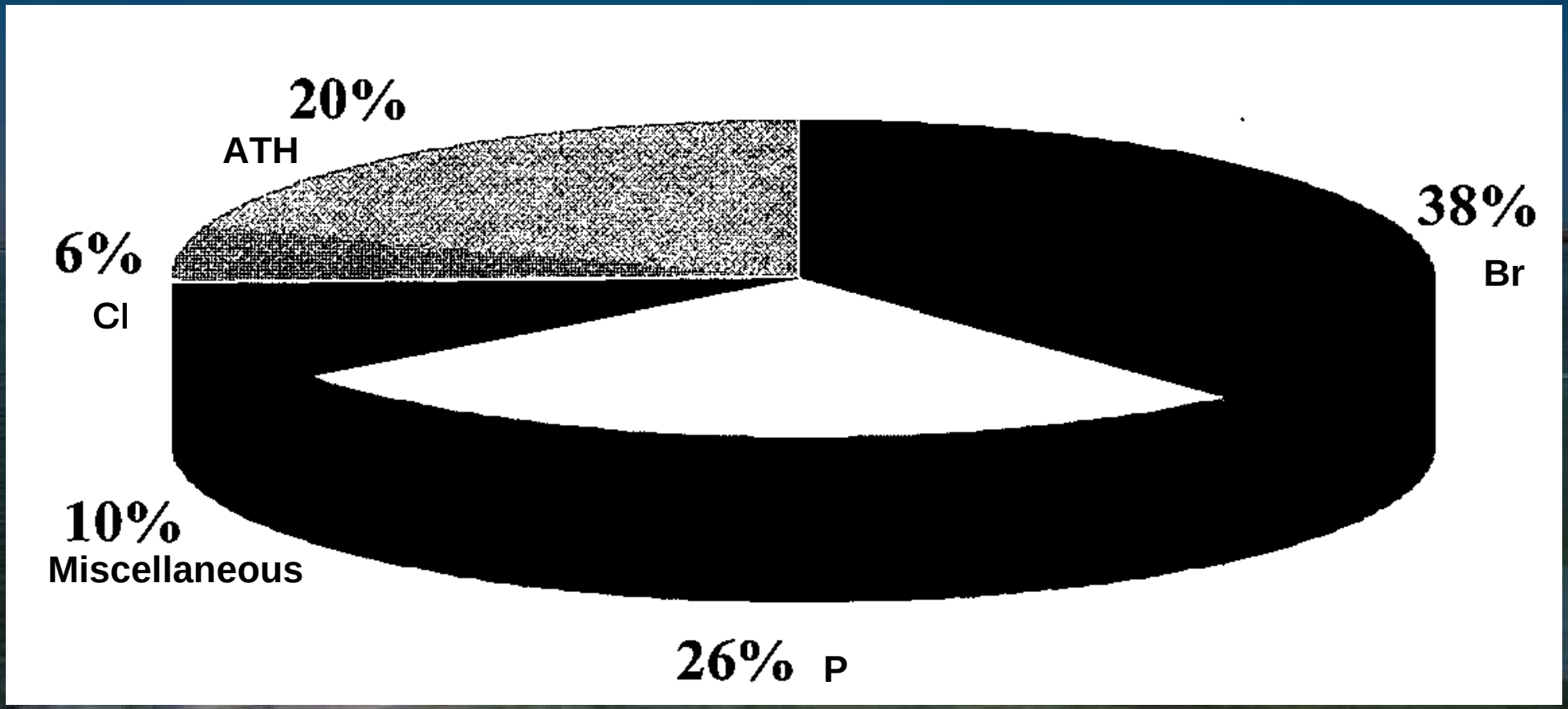





Containing Flame Retardants

Flame Retardants Worldwide Market

2,700 MM$ in 2005 – Bromine 38%



Miscellaneous include : inorganic phosphates, melamine, MG(OH)2, boron and Molybdenum compounds

February 14th 2005

100m high Windsor Tower in Madrid catching fire and completely destroyed.

The Background to VECAP Why use Flame Retardants?

Every day in Europe :

12 fire victims and 120 severely injured
75 % of victims are in their homes

Economic damage : +/- 25 billion Euro's per year

In the UK since 1988 furniture regulation:

3200 lives saved 1988-2000

29000 less non-fatal injuries

Flame retardants and other technologies are a critical part of the fire safety solution.

The fire on an old (1980's) European TV self-extinguishes, while the fire in a non fire-safe TV, recently sold in Europe, keeps burning and growing

German Dioxin Ordinance , 16.7.1999

2, 3, 7, 8, - TBDD

1, 2, 3, 7, 8, - PeBDD

2, 3, 7, 8, - TBDF

2, 3, 4, 7, 8, - PeBDF 4 together : 1 ppb max.

Above 4 plus below 4 = Total 8 : 5 ppb max.

1, 2, 3, 4, 7, 8, - HxBDD

1, 2, 3, 7, 8, 9, - HxBDD

1, 2, 3, 6, 7, 8, - HxBDD

1, 2, 3, 7, 8, - PeBDD

Br-FR by RESIN APPLICATION IN JAPAN

RESIN	Br-FR
ABS	Deca,TBBA,Br-PC Olygomer, TAIC-6B,BEO,Br-PS, Ethylene-Bis(Tetrabromphtalimide) Decabromodiphenylethane, Tris(TBNPA)phosphate Br-Aromatic Triazine
EPS	TBBA-Bis(Allylether),HBCD TBP-Allylether,Tetrabromethane
HIPS	Deca,TBBA,HBCD, Ethylene-Bis(Tetrabromphtalimede) BEO,Tris(TBNPA)phosphate Decabromodiphenylethane Br-Aromatic Triazine TBBA-Bis(2,3Dibrompropylether)

PP	TBBA-Bis(2,3Dibrompropylether) Deca,TBBS,HBCD TBBS-Bis(2,3Dibrompropylether) Decabromdiphenylethane Tris(TBNPA)phosphate Br-Aromatic Triazine
PE	Deca, Decabromdiphenylethane TBBS,TAIC-6B TBBS-Bis(2,3Dibrompropylether)
PC	TBBA, Br-PC Olygomer,BEO
PMMA	Tris(TBNPA)phosphate PBB-MA,PBB-PA TAIC-6B, BEO TPB-EO-Acrylate

PBT	Deca,TBBA-2EO,TBBA-4EO
	Br-PC Olygomer,PBB-PA
	BEO
	Ethylene-bis(Tetrabromphtalimide)
	Decabromodiphenylethane
PET	Deca,Br-PC Olygomer,BEO
	Br-PS,TAIC-6B
	Ethylene-Bis(Tetrabromphtalimide)
	Decabromdiphenylethane
NYLON	Deca,Poly-Dibromphenyleneoxide
	Br-PS,BEO,Br-PC
	Decabromdiphenylethane
	Ethlene-Bis(Tetrabromphtalimide)
PVC	Deca
EPDM	Deca,Decabromdiphenylethane

EPOXY (laminate,BEO,)	**Deca,HBB,TBBA,TBP,BEO, Br Aromatic Triazine Dibromcrezylglycidylether Dibromphenylglycidylether**
Phenol	**TBBA,TBP,BEO**
URETHANE FOAM	**DBNPG,TBNPA,TBBA-2EO**
URETHANE ELASTOMER	**Deca,BEO**
UPET	**TBBA-2EO,DBNPG,TBNPA BEO**
DCPD	**Deca,Br-PS**
Silicone (Rubber)	**Deca,Decabromdiphenlyethane**

TEXTILE (Acrylic,SBR,PP,Polyester,Cotton)

Deca,HBCD,Pentabromtoluene
TBBA-2EO
Tris(TBNPA)phosphate

Adhesive,Adhesive Tape,Paper,Paint,Ink
Plywood

Deca,TBBA-2EO,HBCD
Ammoniumbromide
Tris(TBNPA)phosphate
Decabromdiphenylethane

Outlook

The demand for bromine based products will grow at an average rate of 2-2.5% per year (2% in the first 3 years and later 2.7%)

- **Major drivers and growth areas:**
  - **Adoption of fire safety regulation.**
  - **New applications (Mercury reduction, ….)**
  - **Organic growth in the various applications, following growth of the global economy.**
- **Offset by:**
  - **Continued phased-out of MBr**
  - **Decline of Deca and HBCD**
  - **Emergence of non-halogen substitutes for BFR's.**

Reference

1. ICL-IP Slides, Estimated by ICL-IP
2. ICL-IP HP
3. ICL-IP Catalogue
4. VECAP Eco-Design Presentation, Hirayama

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