



# **Influence of Technological Revolutions on Salt Production**

**Sergio A. Moreno**  
Asociación Mexicana de la Industria Salinera

# Contents

- Agricultural Revolution
- Urban Revolution
- Irrigation Revolution
- Metallurgical Revolution
- Pastoral Revolution
- Mercantile Revolution
- Industrial Revolution
- Thermonuclear Revolution and Information and Communication Technologies (ICT).

# Agricultural Revolution (8000 BCE)

Table 1. **Agricultural Revolution. Influences on salt production**

Civilizations and technological evolution	Influences on production, uses and trade of salt
<ul style="list-style-type: none"> <li>• Began in Mesopotamia, Egypt (8000 BCE)</li> <li>• India (6000 BCE)</li> <li>• China (5000 BCE)</li> <li>• Europe (4500 BCE)</li> <li>• Tropical Africa (3000 BCE)</li> <li>• America (2500 BCE).</li> </ul> <p><u>Technological innovations:</u></p> <p>First agricultural villages and domestic animals</p>	<p><b>China:</b> Traces of salt crops in Yuncheng Lake, Shanxi (6000 BCE).</p> <p><b>Egypt:</b> from 3000 BCE used salt to cure meat, fish and ham. Exported salted fish to Libya and Ethiopia for salt-preserving properties.</p> <p><b>Germany:</b> Salt production in Halle (3500 BCE to 900 CE).</p>

# Agricultural Revolution, continue

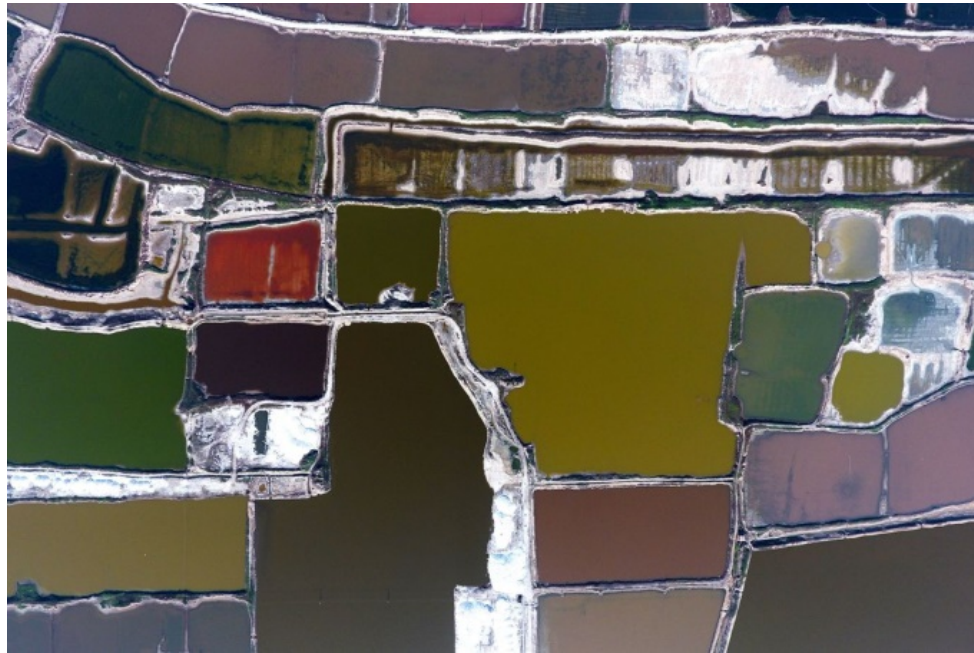


Fig. 1. Yuncheng Lake, Shanxi, China  
Zhan Yan

# Urban Revolution (5000 BCE)

Table 2. **Urban Revolution. Influences on salt production**

Civilizations and technological evolution	Influences on production, uses and trade of salt
<ul style="list-style-type: none"> <li>• Mesopotamia (4000 BCE.)</li> <li>• Egypt (4000-3000 BCE.)</li> <li>• India (2800 BCE)</li> <li>• China (before 2000 BCE)</li>   <li>• Phoenicia (2000-1000 BCE)</li> <li>• Etruscans (9th century BCE)</li> <li>• Athens (6th century BCE)</li> <li>• Rome (before 3rd century BCE)</li>   <u>Nomadic Pastoral Headquarters:</u> Hyksos (1700 BCE), Hittites (1600 BCE), Achaeans (1200 BCE), Huns (200 BCE), Teutons (300) Vandals (400), Visigoths (400)              <u>Technological innovations:</u> plow, wheel vehicles, animal traction, stone building, sailboats.         </ul>	<p>First war for salt in <b>China</b>. "Yellow Emperor" <b>Huandi</b> (2698-2598 BCE).</p> <p><b>Greece.- Aristotle</b> (384–322 BCE) wrote about the origin, <i>salinity and evaporation of the sea</i>. Salt was exchanged for slaves.</p> <p><b>Rome.- Ancus Marcius</b> (641-616 BCE) ordered the construction of <b>salt pans of Ostia</b> to avoid relying on the Etruscans.</p> <p>The <b>Via Salaria</b> was the first great Roman road to transport salt.</p> <p>The distribution of salt in the seas was one of the causes of the <b>Punic Wars</b> (264-146 BCE).</p>

## Urban Revolution, continue



Fig. 2. Huang Di, the Yellow Emperor

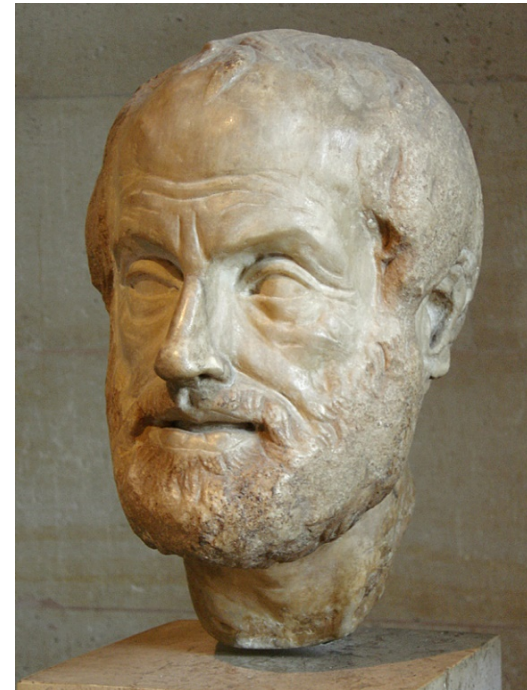


Fig. 3. Aristotle, Louvre Museum

# Irrigation Revolution (2000 BCE)

Table 3. Irrigation Revolution. Influences on salt production

Civilizations and technological evolution	Influences on production, uses and trade of salt
<ul style="list-style-type: none"> <li>• Mesopotamia (Akkadian and Babylonian, 2350 BCE and 1800 BCE)</li> <li>• Egypt (2070 - 1750 BCE).</li> <li>• China (1122 BCE -1644 CE): Dynasties Zhou, Ch'in, Han, Tang, Ming and Ch'ing.</li> <li>• India (Maurya and Gupta, 327 BCE and 320 BCE).</li> <li>• America: Mayan (2000 BCE-900 CE), Aztecs (1325-1521), Incas (1200-1533).</li> </ul> <p><u>Technological innovations:</u> copper metallurgy, bronze, ceramics, Ideographic writing, numeric notation, weight systems, accounting measures, distribution of food, astronomy, educational institutions.</p>	<p><b>China</b></p> <ul style="list-style-type: none"> <li>• In Zhou dynasty the <b>first document on salt production and trade</b> was made (450 BCE).</li> <li>• Yi Dun used <b>metal casseroles to evaporate brine</b> for the first time in the world.</li> <li>• In Ch'in Dynasty used ancient writings (Guanzi, 300 BCE) to manage salt production.</li> </ul> <p><b>India.-</b> Gupta Empire exerted a tax on salt</p> <p><b>America</b></p> <ul style="list-style-type: none"> <li>• <b>Mayan</b> used salt for birth control, epilepsy, and labor pain. Even obtained salt from plants.</li> <li>• <b>Aztecs</b> had warehouses with salt and food taxed from other cultures.</li> <li>• <b>Incas</b> the mindalás group exchanged products such salt.</li> </ul>



## Irrigation Revolution, continue

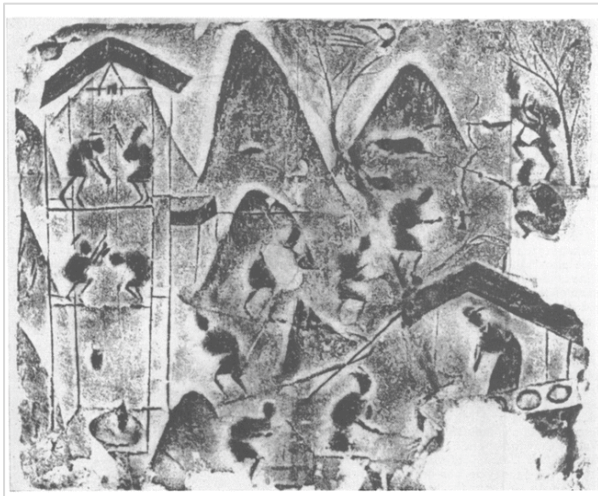


Fig. 4. **Salt production in Szechwan, China**  
Han Dynastie / Rudolph, R.C.



Fig. 5. **Men Preparing Fish, Egypt**  
Tomb Puyemré / Metropolitan Museum of Art



Fig. 6. **Uixtocihuatl, Aztec goddess of salt**  
Matritense Codex



# Metallurgical Revolution (1000 BCE)

Table 4. Metallurgical Revolution. Influences on salt production

Civilizations and technological evolution	Influences on production, uses and trade of salt
<ul style="list-style-type: none"> <li>Assyrians (12<sup>th</sup> to 7<sup>th</sup> century BCE).</li> <li>Achaemenian (6<sup>th</sup> to 8<sup>th</sup> century BCE).</li> <li>Hellenic (5<sup>th</sup> to 1<sup>st</sup> century BCE).</li> <li>Carthaginian (6<sup>th</sup> to 2<sup>nd</sup> century BCE).</li> <li>Roman (1<sup>st</sup> to 4<sup>th</sup> century CE).</li> <li>Byzantine (6<sup>th</sup>-10<sup>th</sup> century CE).</li> </ul> <p><u>Technological innovations:</u>            Manufacture of tools, weapons and metal parts.            Coin minting, Construction of hydraulic machines. Marine lighthouses.</p>	<p><b>Rome.</b></p> <ul style="list-style-type: none"> <li>The Legions received their payment in salt to conserve foods and to exchange it (<b><i>salarium</i></b>: payment of salt).</li> <li><b>Magnus Aurelius Cassiodorus</b> (485-585 CE) emphasized the importance of salt in <i>Variarum Libri</i>.</li> </ul> <p><b>Rest of Europe</b></p> <ul style="list-style-type: none"> <li><b>Hallstatt period</b> (900-400 BCE)</li> <li><b>La Tene period</b> (450 BCE -1 CE)</li> <li><b>Gallo-Romans</b></li> </ul>

# Metallurgical Revolution, continue



Fig. 7. Salt sources in the Graeco-Roman world / Harding A. -Redrawn after Carusi-

# Metallurgical Revolution, continue



DATE	DOCUMENT	PLACE	COMMODITY	AMOUNT stated	litres	PRICE stated	asses	ASSES/L	ANNOTATION
47 AD	P.Mich. V 245	Tebtunis	ἄλς καλός	1 metron	c. 3.9	2 obols 4 chalci	1 2/3	c. 0.43	minimum price (salt merchants)
47 AD	P.Mich. V 245	Tebtunis	ἄλς λεπτός	1 metron	c. 3.9	2 obols	1 1/3	c. 0.34	minimum price (salt merchants)
47 AD	P.Mich. V 245	Tebtunis	ἄλς λεπτότερος	1 metron	c. 3.9	1 obol 4 chalci	1	c. 0.26	minimum price (salt merchants)
111 AD	Tab.Vind. 186	Vindolanda	sal	≥85 pondera	c. 23.2*	≥2 asses	≥2	c. 0.52**	purchase by soldier through Audax (merchant?)
150–199 AD	SB XIV 11960 col. 1	Oxyrhynchites	ἄλς	2 metra	c. 7.8	2 drachmas 2 chalci	4 1/6	c. 0.53	estate's account
258–259 AD	P.Lond. III 1170 verso col. 3	Theadelphia	ἄλς	1 metron	c. 3.9	1 drachmas	2	c. 0.51	estate's account
301 AD	Edict. Diocl. 3.8	Roman Empire	sal	1 castrensis modius	c. 11.6	100 denarii communes	-	-	maximum price
301 AD	Edict. Diocl. 3.9	Roman Empire	sal conditum	1 sextarius	c. 0.5	8 denarii communes	-	-	maximum price

\*based on a bulk density of 1.2 kg/l

\*\*based on a price of 12 asses and a bulk density of 1.2 kg/l

**Fig. 8. Prices of salt attested in the Roman imperial period**  
 Stockinger U / Septimius Severus AR Denarius. 201-210 AD..

# Pastoral Revolution (600 BCE)

Table 5. Pastoral Revolution. Influences on salt production

Civilizations and technological evolution	Influences on production, uses and trade of salt
<ul style="list-style-type: none"> <li>• Sassanian Persians (Iran, Mesopotamia, India -3<sup>rd</sup> to 7<sup>th</sup> century CE).</li> <li>• Islam (Middle East, North Africa, Iberian Peninsula, Upper Asia, India, Indonesia, China, and Eurasia (7<sup>th</sup> century).</li> <li>• Ottoman (1460 CE).</li> <li>• Timurid (1370-1526 CE).</li> <li>• Holy Roman (962-1806)</li> <li>• Byzantine (1025-1453)</li> </ul> <p><u>Technological innovations:</u> cavalry, stirrups, horseshoes, animal traction mills, alembics.</p>	<p><b>Islam.</b> Salt taxes in the <b>Caliphate of Cordoba</b> (750 to 1031), <b>Sultanate of Delhi</b> (1300-1526).</p> <p><b>Rudolf I of Germany</b> promoted the royal monopoly on salt production and trade in Central Europe in 1273.</p> <p>The <b>Crown of Castile</b> decreed their royal rights over salt in 1348.</p> <p><b>Origin of the <i>gabelle</i>:</b> France (13<sup>th</sup> century). Salt tax was created in Provence and Marseille.</p> <p>The <i>gabelle</i> was spread throughout France during the <b>Hundred Years' War</b> (1337-1453).</p>

# Mercantile Revolution (1500)

Table 6. **Mercantile Revolution: Influences on salt production**

Civilizations and technological evolution	Influences on production, uses and trade of salt
<ul style="list-style-type: none"> <li>Spain forme the first colonial world empire.</li> <li>Russia carried out a mercantile colonization towards Eurasia.</li> <li>Mercantile capitalism was generated in Holland, later in England and France.</li> </ul> <p><u>Technological innovations.</u> ocean sailboats, maps, paper, printing, hydraulic machines, fire arms.</p>	<p>1550.- <b>Use of coal</b> for production of salt started in Germany.</p> <p><b>Germany</b> had specialists (cameralists) in laws, administration and technology. The title of <b>Salinist</b> was created.</p> <p><b>Mexico</b> (New Spain) in 1555 was developed a technological innovation that required <b>salt for silver amalgamation</b> (Patio process).</p> <p>1710 the <b>Revolta do sal</b> against salt tax and corruption in distribution occurred in <b>Brazil</b>.</p> <p>1801.- <b>Alexander von Humboldt</b> conducted a <b>research and comparative study</b> at the <b>Zipaquirá mine in Colombia</b> with other salt mines in Europe.</p>





Fig. 9 . Reichenhall Saltworks, Germany, 1771  
Von Stubenrauch

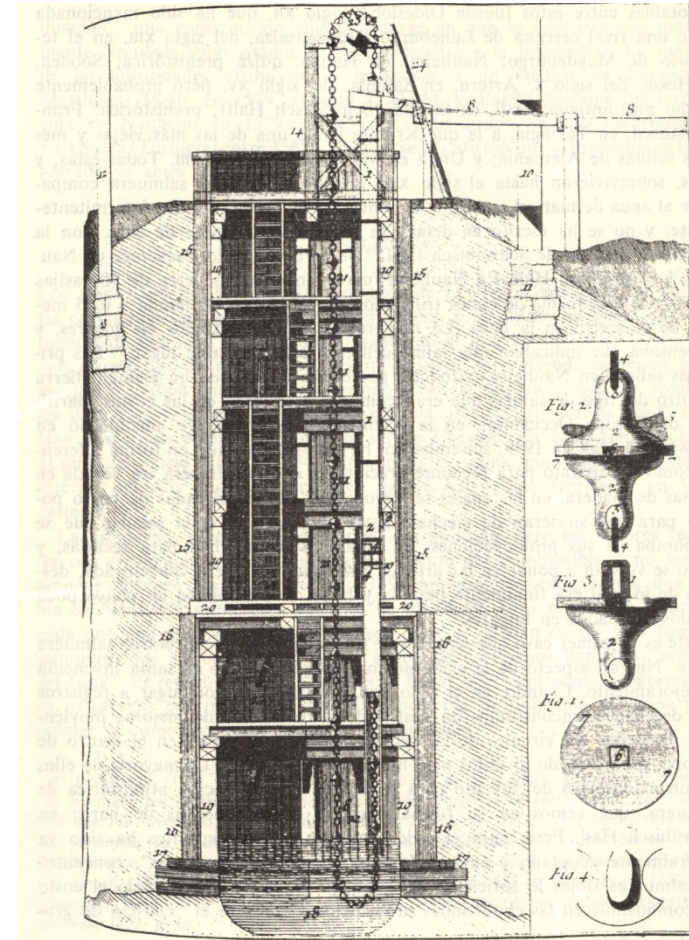


Fig. 10. Pump to raise brine, France, 1785  
Encyclopédie méthodique



# Mercantile Revolution, continue

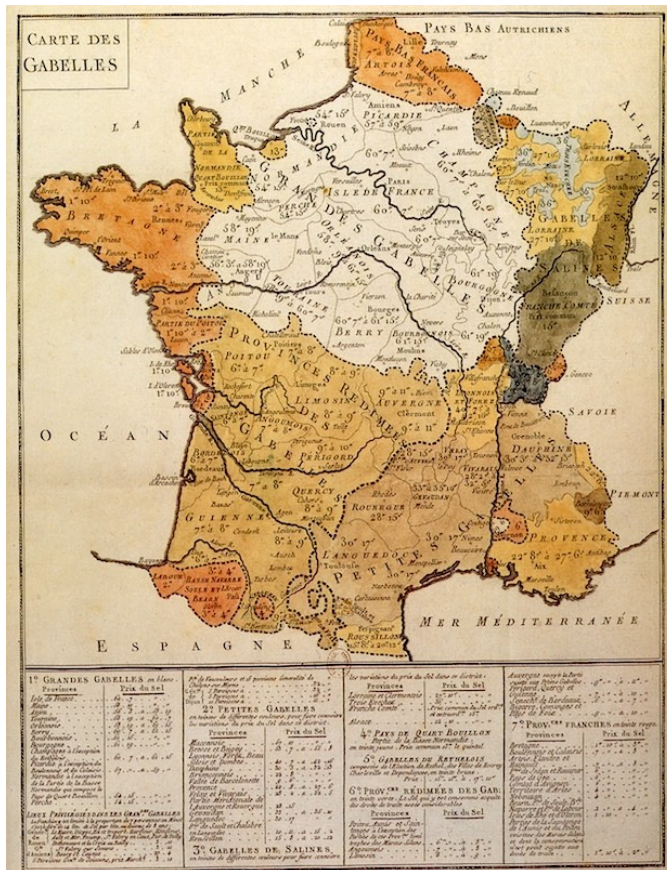


Fig. 11. Map of Gabelles, France, 1781  
Necker, M.



Fig. 12. La Liberté guidant le peuple. 1830.  
Eugène Delacroix, Musée du Louvre

# Industrial Revolution (1800)

Table 7. Industrial Revolution, Influences on salt production

Civilizations and technological evolution	Influences on production, uses and trade of salt
<p>Began in the mid-18<sup>th</sup> century in England and spread to Europe, USA and the rest of the world.</p> <p><u>Technological innovations</u>.- <b>Steam engine, steel, coal, sulfuric acid, soda, textile, chemical</b>, internal combustion, <b>refrigeration</b>, telegraph, telephone, phonograph, photography, film, cement.</p>	<p><u>The steam engine</u> 1799 the first machine of this type was installed in saltworks in Königsborn, Germany.</p> <p><u>Soda and salt</u> 1792. <b>France. Technological innovation</b> in the <b>production of artificial soda using salt</b> to make sodium carbonate.</p> <p>1887 Joseph Duncan installed <b>the first vacuum salt process</b> in New York, USA.</p> <p><u>Electrical energy</u> 1930.- Process of producing salt by electrodialysis.</p>

## Industrial Revolution, continue

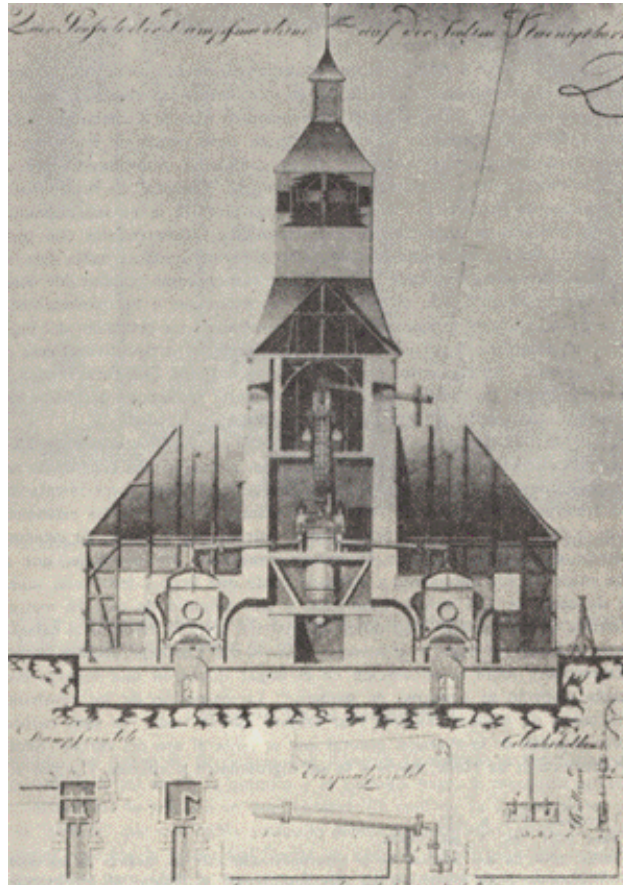


Fig. 13. **Steam engine installed in Königsborn saltworks, Prussia, 1799**  
Bibliothek der Deutsches Museum, Munich

# Thermonuclear Revolution and ICT

## Technological evolution

Nuclear energy, **plastics**, **synthetics**, fertilizers, herbicides, desalination of seawater, solar battery, space navigation, computer, radio telescope, Internet, mobile telephony, global warming.

In the 20<sup>th</sup> century.- **National and international associations of salt companies** were founded in America, Europe, Asia and Africa.

- 1914 the **Salt Institute** was founded in the United States.
- 1957 the European Committee for the Study of Salt was founded in France. Later changed its name to **European Salt Producers' Association**. In 2004 it moved to Belgium.

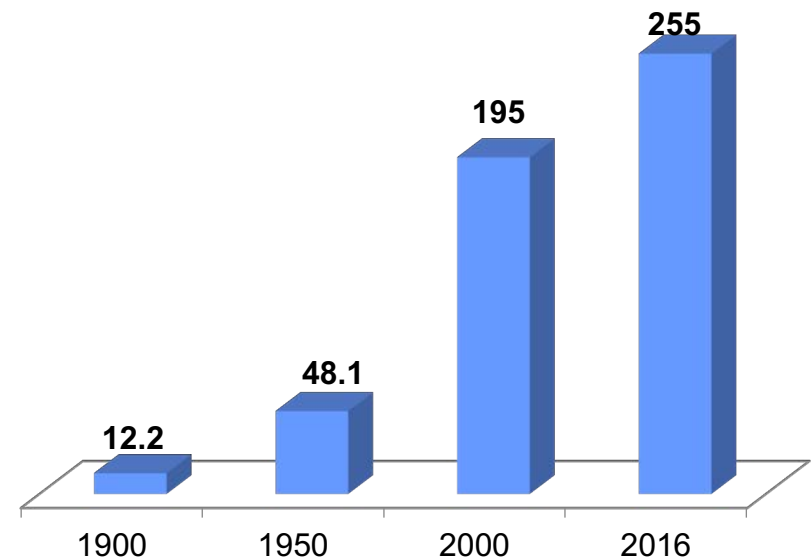


Fig. 14. **World Salt Production in Million Tons, 1900-2016**  
U.S. Geological Survey

# Thermonuclear Revolution and ICT, continue

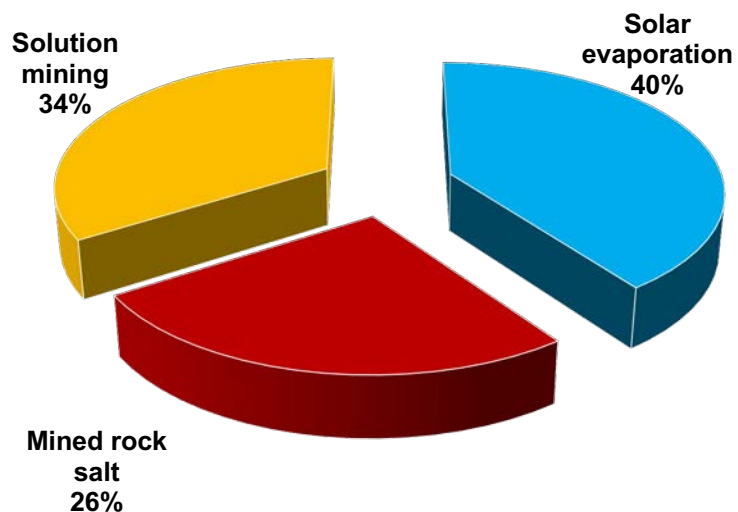


Fig. 15. Methods of world production of salt, 2014  
Roskill

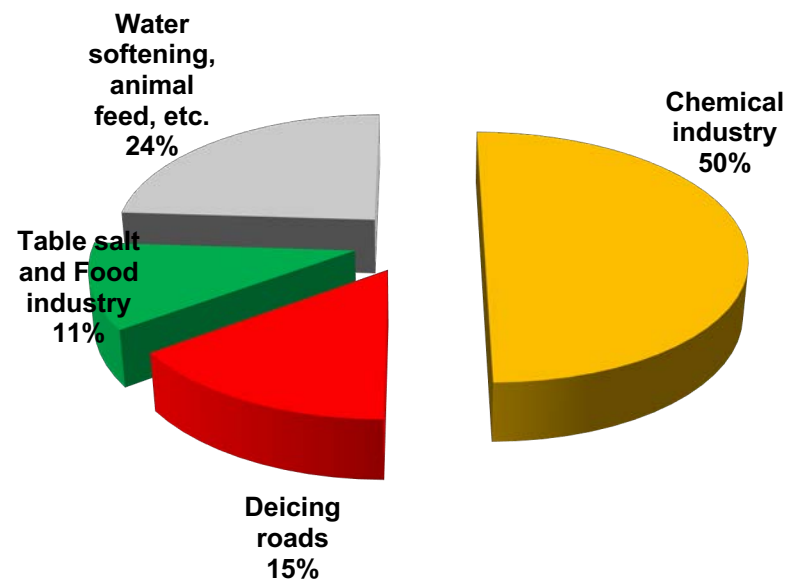


Fig. 16. Uses of salt in the world, 2016  
IHS MARKIT



# Thermonuclear Revolution and ICT, continue

## Salth & Health: Iodized salt. A public health triumph

**UNICEF, 1990.- Iodized salt is the most commonly used vehicle to prevent IDD** (perinatal mortality, mental retardation, brain damage in childhood, goiter).

Countries where IDD were a public health problem were **reduced from 110 in 1993 to 25 in 2015.**

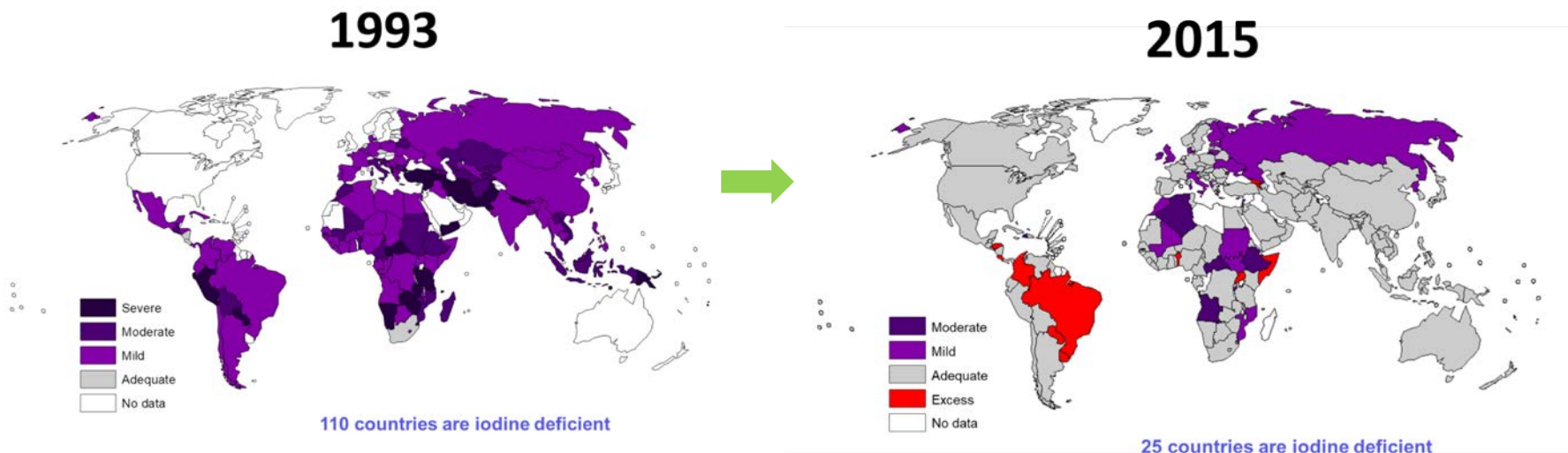


Fig. 17. **Countries with Iodine Deficient, 1993 and 2015**  
Iodine Global Network



# Conclusions

- **Technological revolutions influenced the increase in salt production** and its link with different aspects of human activity.
- The **turning point of technologies applied in the production of salt** was from the **Industrial Revolution** with the use of new energy sources.
- In the **public health** the contribution of the **iodized salt** to prevent the IDD has been **fundamental for the development of different communities**.
- It is necessary to find an **inclusive, objective and respectful dialogue** between international health agencies and the salt industry to report on the benefits of adequate consumption of salt .

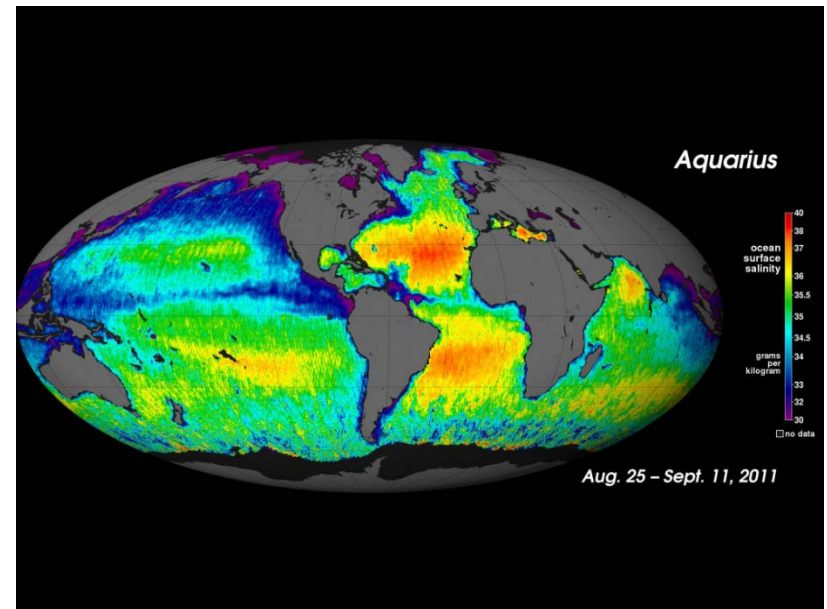


Fig. 18. Map of the salinity of Earth's ocean surface  
NASA



**Sergio A. Moreno**  
[sergiom@amisac.org.mx](mailto:sergiom@amisac.org.mx)