Climate Change, Water Resources and Water Environment

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Geoscience of the water cycle

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- Extreme climate events
- Flooding and drought
- Anthropogenic activities
1. Climate change impact on Water cycle

Water = Water resource?

- Global water volume: about 1.4 billion km$^3$

- Freshwater: around 35 million km$^3$

- Oceans and seas: 96.53%

- Glacial water: 68.69%

- Groundwater: 30.06%

- Salty water: 0.94%

- Others: permafrost 0.86%, lakes 0.26%, rivers 0.006%, soil moisture 0.05%

Source: UNEP
Geoscience of the water cycle

**Karst areas in Europe and proportion of karst groundwater in total water supply (COST65, 1995)**

<table>
<thead>
<tr>
<th>Country</th>
<th>Total area of country km²</th>
<th>Carbonate area %</th>
<th>Percent of groundwater in total water supply</th>
<th>Karst groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>83 856</td>
<td>23,7</td>
<td>98</td>
<td>50</td>
</tr>
<tr>
<td>Belgium</td>
<td>30 513</td>
<td>14</td>
<td>90</td>
<td>31</td>
</tr>
<tr>
<td>Croatia</td>
<td>56 538</td>
<td>40</td>
<td>90</td>
<td>36</td>
</tr>
<tr>
<td>Estonia</td>
<td>45 100</td>
<td>67</td>
<td>80</td>
<td>16</td>
</tr>
<tr>
<td>France</td>
<td>547 026</td>
<td>33</td>
<td>45</td>
<td>25</td>
</tr>
<tr>
<td>Germany</td>
<td>356 910</td>
<td>6,5</td>
<td>70</td>
<td>6,3</td>
</tr>
<tr>
<td>Hungary</td>
<td>93 030</td>
<td>1,45</td>
<td>10</td>
<td>2,8</td>
</tr>
<tr>
<td>Ireland</td>
<td>70 282</td>
<td>45</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Italy</td>
<td>301 230</td>
<td>14,2</td>
<td>?</td>
<td>23</td>
</tr>
<tr>
<td>Poland</td>
<td>312 680</td>
<td>9,8</td>
<td>14,3</td>
<td>4</td>
</tr>
<tr>
<td>Portugal</td>
<td>92 082</td>
<td>2,3</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Romania</td>
<td>237 499</td>
<td>1,8</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Slovakia</td>
<td>48 900</td>
<td>6,3</td>
<td>85</td>
<td>27</td>
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<tr>
<td>Slovenia</td>
<td>20 251</td>
<td>43</td>
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<td>50</td>
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<tr>
<td>Spain</td>
<td>504 750</td>
<td>22,3</td>
<td>25</td>
<td>12,5</td>
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<td>Switzerland</td>
<td>41 290</td>
<td>20</td>
<td>80</td>
<td>15</td>
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<tr>
<td>Turkey</td>
<td>780 776</td>
<td>33</td>
<td>6</td>
<td>1,5</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>244 820</td>
<td>22</td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>
In Florida, US, 51% of the water supply is from karst springs.
There is evidence that the global climate is changing (WWAP)

• UN: More than one in six people worldwide (894 million) don’t have fresh water for their basic needs.
• By 2025, 1 800 million people will be living in countries or regions with absolute water scarcity, and 2/3 of the world population could be under stress conditions (Source: FAO)
The global water cycle (from Shiklomanov (1993)).
Geoscience of the water cycle

- Under the influence of global warming
- Evaporation increase
- Water cycle accelerates

- Some regions would be subjected to frequent flooding, some drought

Lingshui spring, Guangxi, China
Discharge in dry season: 4\(m^3/s\)(1977), 2\(m^3/s\)(2000)
From November 2009 to April 2010, for example, an extreme long drought event hit the southwest China karst area and cause a severe drinking water difficulty of more than eighteen million local people.
Huangguoshu waterfall of Guizhou in winter, 2008

Influenced by drought, Huangguoshu Waterfall is almost dry up in April, 2010.
Catastrophe Looms As Ice Sheets Shrink

- The world’s glaciers and ice sheets show signs of melting faster than previously believed; some predict sea levels will rise one meter by 2100. Helheim Glacier, in Greenland.

Scientists warn inaction may put coastal cities under water
Vulnerable Regions

Scientists are predicting one meter or more of sea-level rise by 2100. Should that occur, large amounts of land in coastal regions would be subjected to frequent flooding and possible inundation. Low-lying areas in Louisiana, Florida and southern Asia are especially vulnerable, and some coastal cities like New York and San Francisco also face threats along their shorelines.
Impact of both Climate Change and Human activity (groundwater exploitation)
Some researchers (Liu, 2010, V. Montety et al., 2011) have stressed the role of terrestrial aquatic photosynthesis in processing dissolved inorganic carbon (DIC). They found that the net photosynthetic uptake of DIC by aquatic organisms on the continents and in Ichetucknee river could be as large as 233 Tg C/a and 0.5 g/m/day respectively.
In a word, to obtain accurate estimates of rock weathering-related carbon sinks from river chemical data, both the concentrations of DIC and of autochthonous TOC must be considered.
2. Water pollution and water resources

- Urbanization
- Landuse
- Industry
- Mining etc.
Cadmium pollution in Longjiang River, Guangxi

Lalang underground river and Longjiang River, Guangxi, China
Fig. 1 PAHs atmospheric deposition fluxes with season and precipitation

Fig. 2 PAHs concentrations in air with karst topography

Fig. 3 PAHs concentrations in soil with karst topography

Fig. 4 PAHs concentrations in sediments along Bailang underground river basin

Fig. 5 PAHs concentrations in water along Bailang underground river basin

Note:
Fig. 1 and Fig. 2 showed that POPs sources come from atmospheric transportation.
Fig. 2 and Fig. 3 showed that Great doline has “cold trap effect” to POPs.
Fig. 4 and Fig. 5 showed that the water and sediment had been polluted by POPs transported.
3. Suggestions

• Hydrogeologist, hydrologist, meteorologists, environmentalist should work together to better understand how climate change impacts the earth’s water cycle, especially underground water cycle;

• To launch some programmes or projects to protect key watersheds from changes in human landuses (urbanization, industry, mining etc.) that can catastrophically contaminate water supplies.
• Strengthen the study on carbon sink related to water cycle
• Set up new alternative undergroundwater source for water supply, mitigating surface water supply induced by extreme drought or accident event


6. William B. White, 1988, Geomorphology and Hydrology of Karst Terrains, Oxford University Press, P154, Table 6.1

7. Derek Ford & Paul Williams, 1989, “Karst Hydrology”. In: Karst Geomorphology and Hydrology, Unwin Hyman, P. 127-170


Thank you for your attention!