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To accompany the peer-reviewed article by Mohamed Kassas, Ph.D.:
"International Water Facility" (February 2001)
http://www.actionbioscience.org/environment/kassas.html

Water Everywhere: Is There Enough to Drink? (May 2002)

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Grades & Levels:

- **Handout 1:** high school (general)
- **Handout 2:** high school (advanced/AP) – undergraduate (year 1)

Time Recommendations:

- **Handout 1:** 2 class periods – 1 week
- **Handout 2:** 1-2 weeks

NSES (USA) Content Standards, 9-12:

- **NSES 2.1.** Science as Inquiry: abilities necessary to do scientific inquiry
- **NSES 5.2**. Earth and Space Science: geochemical cycles
- **NSES 7.2**. Science in Personal/Social Perspectives: population growth
- **NSES 7.3.** Science in Personal/Social Perspectives: natural resources
- **NSES 7.6.** Science in Personal/Social Perspectives: sc. & tech. in local, national & global challenges

Learning Objectives: Students will…

- perform calculations and analyze data for freshwater availability and consumption
- examine issues in shortages and pollution of freshwater sources
- research characteristics of physical geography and relate these to the hydrological cycle

Key Words Include:
aquifer, arid, cubic meter, cubic kilometer, conversion of units, desalination, desertification, drought, dryland, ground water, hydrogeology, hydrologic cycle, irrigation, per capita, physical geography, salinization, sinkhole, watershed, water stress

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Preparation

Article Discussion:

- Distribute copies or have students download the article "International Water Facility" at http://www.actionbioscience.org/environment/kassas.html
- Review the key words with students or assign the definitions as individual research.
- Questions on the article are provided on page 2. You may wish to ask the questions in class for a verbal response or ask students to form teams and write their answers.

Student Handouts:

- Both handouts contain several activities that require research, mainly on the Internet, as well as visual, written, or oral presentations.
- Activities can be conducted in whole or in part individually, in pairs, or in small groups.

- For activities with charts and tables: Students will need access to the Internet and/or library to research information. They will need access to a good world atlas that will allow them to see the topographical characteristics of the countries so they can make inferences about the water cycle. Students will likely need to review the conversion of units, especially working with cubed units.

For Educators: Article Discussion

About the article by Mohamed Kassas, Ph.D.:
"International Water Facility"
http://www.actionbioscience.org/environment/kassas.html

Have students read the article "International Water Facility" on their own in class or as a homework assignment before asking or assigning the following questions about the article:

Article Content Questions:

1. What is the author asking world organizations to do?
2. What percentage of the world had a shortage of drinking water when Dr. Kassas wrote the article?
3. According to a 2002 United Nations (UN) report, how will this percentage change by 2032?
4. What percentage of the world's water is freshwater?
5. What provides most of our freshwater?
6. How much freshwater is provided by lakes and river systems?
7. Is most of the ground water near the surface?
8. Does the author believe we can solve freshwater shortage problems? How?
9. What is desalination?
10. What are the main problems with current desalination technology?
11. How much land in the world is arid?
12. If we had additional freshwater resources now, what would be the benefits?

Article Extension Questions:

1. The author won a UN prize for his work in desertification. What do you know about desertification?
2. Has your local government restricted use of tap water recently? Explain.
3. Have you read about or seen news on TV about drought? Summarize one such story.

Water Everywhere: Is There Enough to Drink?
Student Handout 1

1. Renewable Water Resources

In the article, "International Water Facility" by Mohamed Kassas, the author describes water availability in terms of cubic meters per capita per year. The Worldwatch Institute describes countries having less than 1700 cubic meters per capita per year of available freshwater as facing water stress. Calculate the per capita availability of freshwater for the 17 countries in Table 1.

Keep in mind that your calculations will result in estimates, not factual figures because in Table 1:

- The data for water resources was collected prior to 1998. Check the WorldWatch Institute web site for updates.
- Population figures provided are for year 2001. Check the Tiscali Online Reference for annual updates.

Your task is to:

a) convert the water resources estimates in cubic kilometers to cubic meters (1 km = 1000 m)
b) determine the cubic meters per capita per year and record your values in the last column

Table 1: Annual Renewable Water Resource and Population Estimates for 17 Selected Countries

Country	Population	Annual Renewable Water Resources (km^3/yr)	Annual Renewable Water Resources (m^3/yr)	Annual Renewable Per Capita Water Resources (m^3/person/yr)
Egypt	57,673,000	86.8		
South Africa	40,435,000	50.0		
Canada	29,248,000	2901.0		
Guatemala	10,322,000	116.0		
Mexico	87,341,000	357.4		
USA	255,020,000	2478.0		
Brazil	153,792,000	6950.0		
Peru	23,088,000	40.0		
China	1,200,000,000	2800.0		
Israel	5,423,000	2.2		
Jordan	4,936,000	0.9		
Turkey	58,775,000	200.7		
France	57,850,000	198.0		
Netherlands	15,385,000	90.0		
United Kingdom	57,998,400	120.0		
Russia	148,366,00	4498.0		
Australia	17,803,000	343.0		

Discussion

Discuss the following after completing the table:

- Which countries are experiencing water stress according to the Worldwatch Institute Guidelines?
- What characteristics of these countries contribute to their water stress? (You should locate these countries on a map to examine their geography. You may also find information about these countries by searching the Internet for sites about these countries.)

2. Water Usage Histogram

Graph the water usage data from Table 2 in a histogram arranging the countries in order from least populated to most populated (2001 data). The water percentages in Table 2 are based on 2000 estimates, that were projected in the 1990s, so your calculations will result in estimates, not factual figures.

Table 2: Percentage of Water Resources Devoted Annually to Domestic, Industrial and Agricultural Uses for 17 Selected Countries

Country	Domestic Use	Industrial Use	Agricultural Use	Population
Egypt	6	8	86	57,673,000
South Africa	17	11	72	40,435,000
Canada	11	80	8	29,248,000
Guatemala	9	17	74	10,322,000
Mexico	6	8	86	87,341,000
USA	12	46	42	255,020,000
Brazil	10	5	85	153,792,000
Peru	19	9	72	23,088,000
China	6	7	87	1,200,000,000
Israel	16	5	79	5,423,000
Jordan	22	3	75	4,936,000
Turkey	16	11	72	58,775,000
France	16	69	15	57,850,000
Netherlands	5	61	34	15,385,000
United Kingdom	23	73	4	57,998,400
Russia	19	62	20	148,366,00
Australia	65	2	33	17,803,000

Discussion: After completing the graph, discuss if there is a relationship between water usage and population size. Find the countries in an atlas or on a globe and determine if geographic size influences the water usage patterns.

3. Waste Not! Campaign

Form an advocacy group for smart water usage. Create a poster or flyer that lists DOs and DON'Ts for your school and one for the citizens of your community, e.g., *DO: Use laundry machine for full loads only.*

4. Water Consumption Trivia

a) List at least 20 interesting facts about water consumption in your country. For example: *1. It takes 6 tons of water to make a ton of steel. 2. Each toilet flush uses 1.6 gallons of water.*
b) Create a trivia quiz using the items on your list. For example:
How much water does it take to make a ton of steel? a) 1 ton b) 6 tons c) 10 tons
c) Exchange your quiz with classmates and ask them to complete it. Be prepared to provide answers.

5. Sinkhole!

Write a newspaper feature with a title similar to "A sinkhole swallowed my friend's house!" In your story, describe the hydrogeologic circumstances that led to the catastrophe. If you're not familiar with sinkholes, look up news stories about sinkholes that have appeared in Florida, USA.

Water Everywhere: Is There Enough to Drink?
Student Handout 2

1. Redistribution of Water
Over the past 100 years, people have built networks of canals, dams and reservoirs to such an extent that the redistribution of freshwater from one place to another has resulted in a small but measurable change in the wobble of the earth as it spins. Prepare an essay that examines this effect and its current and future ramifications. Include a diagram or other illustration to show the change in earth's wobble.

2. Agricultural Water Usage
The largest single consumer of water is agriculture. As an advocate for smart water usage, prepare a written or visual presentation for an agricultural exhibit. Include:

- statistics about ground water depletion by agriculture
- the potential problem of salinization due to agricultural usage of land
- statements and facts to convince farmers to switch from spray to drip irrigation or other method

3. Aquifers
Create a presentation for a hydrogeology student competition about aquifers. Choose *one* of the aquifers listed for your presentation. Focus on degree of exploitation to recharge and conservation efforts, if any.

- Ogalalla Aquifer *or* Edwards Aquifer, USA
- Saq Aquifer, Saudi Arabia
- Hermosillo Aquifer, Mexico
- Great Artesian Basin Aquifer, Australia
- HaHof Aquifer *or* Yarqon-Taninim Aquifer, Israel
- Guarani Aquifer, South America

4. Desalination
You work for a desalination consulting firm. Create a presentation for a business convention that

- illustrates these desalination processes: reverse osmosis and electrodialysis
- provides a cost analysis
  - Contact your local water authority to find out: a) costs to provide 1,000 liters of freshwater to the community, b) how much water is used in its jurisdiction annually.
  - Compare annual cost of providing water using current technology with the potential cost of desalinated water (see note #3 in Dr. Kassas' article references for cost examples).

5. Desertification
Every year, desertification is devouring about 20,000 square miles of land worldwide. Write a report for an environmental conference that examines desertification in *one* of these geographical areas: Sudano-Sahelian zone of Africa, the Middle East, India, China. Include maps of affected geographical areas.

6. Water Supply in Cities
Choose a large city, one with significant sprawl, in your country. Create a written or visual presentation that illustrates:

- water consumption and population growth (graph or chart) spanning the last 10 to 30 years
- how population growth has impacted water resources over these decades
- current problems facing water quality and availability in the city
- solutions proposed by scientists and politicians, if any
- your personal conclusion that includes suggestions on how to alleviate the problems