ground water

Technical Commentary/

What Does "Water Quality" Mean?

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Introduction

In January 2005, the Jordan Valley Water Conservancy District (JVWCD), a public agency that supplies water to much of Salt Lake County, Utah, drilled an exploratory test well. The well proved to be reasonably productive, and chemical analyses of the water showed that it met all primary water-quality maximum contaminant levels (MCLs) and most secondary standards for drinking water as established by the Utah Division of Drinking Water. But despite this, the water was not considered to be of sufficient quality for Salt Lake County's public water supply. The problem was that the water's temperature, as high as 83°F (28°C), made it too warm for the taste of JVWCD's customers. Much of the ground water available in the Jordan Valley is recharged from snowmelt originating in the nearby Wasatch Range and is relatively cold (Thiros and Manning 2004). Typical JVWCD water supplies have temperatures ranging from 50°F to 60°F (10°C to 15°C). However, upwelling hydrothermal waters associated with faulting that formed the Jordan Valley were apparently affecting the test well, causing the unusually warm temperature. When people turn on the "cold" water tap, they expect the water to be cool, not warm. The quality of the water from the new test well, therefore, was too poor to be put into distribution.

The term "water quality" has been in general use for the last hundred years or so. But to many people, this term is somewhat vague and poorly defined. Does "good" water quality mean the absence of man-made or natural contaminants? Does it mean that such contaminants may be present, but that the concentrations are below MCLs? Or, as in the example just given, does it mean that it simply satisfies the expectations (cold vs. warm) of the people drinking it? In other words, does water quality depend on the characteristics of the water itself, or is it merely what people happen to like?

The Aesthetics of Water Quality

We need not begin from scratch to arrive at a definition of water quality. Beginning at least with Plato, understanding what constitutes "good" or "bad" has been an active area of philosophical inquiry. In 1790, Emanual Kant argued that assessments of quality were *judgments* based partly on objective characteristics but interpreted within the a priori subjective framework of the observer (Wenzel 2005). Quality, therefore, can never be solely objective or solely subjective, but rather is always a combination of the two. Furthermore, because everybody's a priori subjective framework is different, judgments of quality necessarily differ between people.

A logic diagram illustrating Kant's aesthetic framework (Figure 1) suggests why the term "water quality" can mean so many different things to different people. To take an extreme example, the notion of better water quality would be very different for someone casually turning on a cold water tap in Salt Lake City than, say, for a Somali nomad in danger of dying from dehydration in the desert. The important point is that judgments of better or poorer water quality are not static but change from person to person and from situation to situation. Although the objective characteristics of water may stay the same, the subjective needs of humans vary enormously. Quality is more like an *event* (Pirsig 1974) that happens when an object interacts with the subjective needs or expectations of people (Figure 1).

The Nature of Water-Quality Standards

Water-quality standards are an example of what Kant would consider aesthetic judgments. On one hand, there are the objective characteristics of the water (e.g., concentrations of dissolved and particulate matter) to consider. Having reliable analytical methods for assessing the chemistry and microbiology of water has made it

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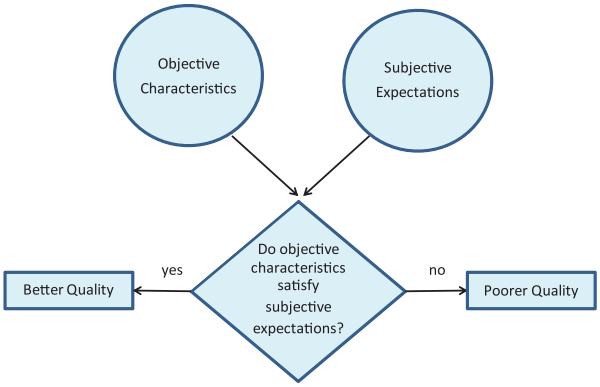

Figure 1. Diagram illustrating Kant's conception of how judgments of better or poorer quality are made.

possible to determine these objective characteristics fairly accurately. But there is always uncertainty associated with analytical methods, and so even here, complete objectivity is not possible. On the other hand, there are also the subjective needs and expectations of the people using the water to consider.

Interestingly, the regulatory process by which water-quality standards are established conforms fairly closely to Kant's aesthetic framework. The Safe Drinking Water Act of 1974, as amended in 1986, gives the EPA authority to establish drinking water standards, and these standards are to be based on the use to which the water is put (http://www.epa.gov/waterscience/standards/about/uses.htm). In the case of water intended for human consumption, the EPA recognizes two categories of standards for water (http://www.epa.gov/safewater/standard/setting.html). The first are *primary,* which limit the levels of specific constituents that can adversely affect public health. In Kant's framework (Figure 1), this corresponds to the objective characteristics of water that have been shown to be detrimental to human health. *Salmonella typhi*, for example, is a water borne pathogen that can cause deadly typhoid fever in humans. Drinking water, therefore, must not contain measurable amounts of *S. typhi*, and these primary standards are legally enforceable. The other category of standards are *secondary* or "aesthetic" in nature. These are nonenforceable guidelines for things like discoloration effects, taste, odor, and color. In Kant's framework (Figure 1), these correspond to the subjective characteristics of water that people tend to prefer. The high temperature of the JVWCD's test well water is an example of how aesthetic characteristics can lower water quality to the point where it's not considered desirable.

Another way that Kant's aesthetic framework is similar to modern regulatory practice has to do with how water-quality standards are changed. The Clean Water Act requires that water-quality standards be reviewed periodically (http://www.epa.gov/waterscience/standards/about/rev.htm). In 2001, for example, the MCL for arsenic in drinking water was lowered from 50 to10 μg/L (*Federal Register* 2001). For years, objective characterization of arsenic concentrations in ground water, carried out by the National Water Quality Assessment (NAWQA) program of the USGS (Welch et al. 1999) as well as by numerous state and local monitoring programs, had shown locally elevated concentrations of arsenic in ground water in parts of the United States. Furthermore, epidemiological studies had shown that higher concentrations of arsenic were associated with increased cancer risk in humans (Chen et al. 1992; National Research Council 1999; Ferreccio et al. 2000; Smith et al. 1998; Ayotte et al. 2006). In other words, objective characterization showed that relatively high concentrations of arsenic exist in parts of the United States, and that cancer risk increased with increasing arsenic concentrations.

But to arrive at a new primary water-quality standard, it was also necessary to consider the subjective needs and expectations of people. This involved years of debate and public comment on alternative proposed standards (Smith et al. 2002). Although arsenic in drinking water increases the risk of cancer in humans, it is also very expensive to treat and poses a problem for communities relying on ground water with naturally high arsenic concentrations. Settling on the 10 μg/L MCL, therefore, was a judgment (in Kant's aesthetic framework) designed to minimize the risk of cancer in humans while minimizing the economic cost of treating water for arsenic. The wisdom of this judgment is and will remain an open question for years to come. But it is a clear example of how the objective and subjective nature of quality affects both the selection of water-quality standards and the rationale for changing them.

Conclusions

"Water quality" is not a vague or poorly defined term at all. It refers to a specific judgment as to how water of given composition fits the perceived needs of the individual, group, or ecosystem using it. At the same time, however, human judgments of water quality are inherently dynamic. The constantly changing technology of objective characterization certainly contributes to the dynamic nature of water quality (e.g., contaminants of emerging concern; Kolpin et al. 2002). But also, because of the subjective component, what is judged to be better or poorer water quality will vary depending on the changing needs of people. The process that regulatory agencies go through to establish water-quality standards implicitly acknowledges the dynamic nature of water quality. We would argue that this dynamic nature should be understood explicitly by scientists and resource managers alike. One benefit of such an understanding is the realization that changing water-quality standards does *not* imply that they are arbitrary or capricious. Water-quality standards *should* change as objective characterization improves or as subjective human needs change.

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