

## Making Waves Episode 45

Effluent-Dominated Desert Streams: That's just the way it flows

[intro]

Hello, my name is Susan Washko, and welcome to Making Waves, brought to you by the Society for Freshwater Science.

Aridlands across the world are losing their streams and rivers to climate change and the overpumping of groundwater for agricultural and urban uses. Climate change causes droughts, reducing rainfall and forcing farmers to pump for irrigation, and urban areas rely on groundwater for the household use of their citizens. Between the pumping and the lack of replenishment due to the low rainfall, groundwater levels in arid regions are dropping. When groundwater levels are low, the water is deeper under the earth's surface, meaning the rivers and streams that get their water from the groundwater table don't have flow, because the water is too deep down to fill the river channel. This is a problem for aquatic life, the habitat for those organisms disappears.

Interestingly, wastewater treatment plants often pipe the treated wastewater into nearby riverbeds. This happens in more than arid areas, for example, the Cuyahoga River receives treated wastewater from adjacent cities. However, in arid areas, the river is totally dry, so the pipes supply the only water for the river to flow again. This made me curious—what are effluent-dominated rivers like?

Today I'll interview two experts on effluent-dominated rivers, Drew Eppheimer and Hamdhani from the University of Arizona in Tucson. Both doctoral students in the School of Natural Resources and the Environment, they study the Santa Cruz River, which gets its flow from Tucson's treated wastewater. Here's what they told me about the river.

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### **1. Ok first question. So Drew, what can you tell me about the history of the Santa Cruz River?**

**Drew:** The Santa Cruz is an international river shared by Arizona and Sonora, Mexico and also is the traditional homeland of the Tohono O'odham. The headwaters begin in Southern Arizona, flow south into Northern Sonora, Mexico. Then the river does a U Turn and crosses the border a second time flowing north past what is now the border community of Ambos Nogales and the City of Tucson on the way to its confluence with the Gila River south of Phoenix, Arizona. In total it's a little over 300 km in length.

The Santa Cruz River has a rich history and culture. This dates all the way back to 10,000 BC when Prehistoric peoples used this area for hunting and gathering. As recently as about 600 years ago, the Hohokam people had many villages throughout this basin and region. They were known for, among many things, their ingenious irrigation techniques, and they used the Santa Cruz River to water their crops. Modern day indigenous tribes such as the Pima and Tohono O'odham (descendants of the Hohokam) have also lived along and used the river for centuries. And the river remains an important part of the history and culture of these Nations.

Right around 1700 Spanish colonization of these lands began including the establishment of missions along the Santa Cruz River. Over the years there were migrations of Mexican campesinos and eventually Anglo settlers to this area as this region grew with cattle ranching and mining operations, and towns/cities began to be developed. Fast forward to the 1930s- after decades of diversions and extensive ground water pumping, the Santa Cruz River dried up. Today groundwater levels are 80 m below the streambed in many areas.

However, also today there are some portions of the river with artificial flow... Discharge from wastewater treatment plants has provided a new and continuous source of water in certain sections of the river. In 1951 wastewater treatment plants were constructed near the US/Mexico border and also in the city of Tucson, and later in 1978 an additional plant was built in Tucson. So these three facilities discharge the majority of their treated effluent directly into the river channel and combined they provide over 50 km of stream flow.

## **2. The water entering the river is treated wastewater. What is the water quality like?**

**Hamdhani:** So yeah, Susan, if you come down to the river you might see that the water is normal, natural river water. So physically, it is clean and clear and no bad smell. Because the water is dominated by treated wastewater discharge, we probably still think that the water is cloudy and maybe emitting a bad smell, but it's not like that in the Santa Cruz River. What we see in the Santa Cruz River as an effluent dominated river now is because of the high quality of processes in the wastewater treatment plant. The case was different before the treatment upgrade in 2014.

So my colleague, Drew Eppheimer, and I study the macroinvertebrate community along with the water quality dynamics in the Santa Cruz River. We collected several physical and water quality parameters periodically in 2018 on the upper reach near Nogales and lower reaches in Marana and the Tucson area. Here, I will say that in general water quality is good, and it's supposed to be healthy enough to support aquatic species such as fish and aquatic insects. Here, one of the examples is oxygen concentration, for example. It's one of the most important water quality indicators. So we found that the concentration is generally at the level that is able to support aquatic species, even though we notice slightly lower concentrations near the outfalls. The same thing with pH, it's usually within the range of normal pH that should be safe for most aquatic species.

However, it doesn't mean there is no issue at all in terms of water quality in effluent-dominated rivers, such as the Santa Cruz River. Here, for example, our study indicated that sometimes nutrient concentrations such as ammonia was found at high concentration that may cause toxicity to very sensitive aquatic biota. Fortunately, we found that this elevated concentration decreased with the flow downstream. The other issue in this system is related to elevated concentrations of emergent contaminants. They include pharmaceuticals, personal care products, pesticides, herbicides, and endocrine-disrupting compounds. The current conventional technology is still relatively unable to remove these chemicals at very small quantity levels.

### **3. When the river was dry, the aquatic organisms must have disappeared. What happened when the river had water again?**

**Drew:** Yes, so there was a period of decades from when the river lost its natural flow until the wastewater treatment plants began discharging effluent into the stream. And so all the living things that depended upon year round water ultimately disappeared when the river dried up. This included aquatic invertebrates and vertebrates- like the insects and fish- as well as a lot of the riparian vegetation.

But as we know, portions of the river began receiving artificial flow from effluent discharge. And with this return of the water, we've seen a return of the aquatic and riparian life. So in one way or another, all of these living things had to recolonize these new portions of the Santa Cruz River. And so all the aquatic life Hamdhani and I are seeing now in the river are relatively recent arrivals.

Even though water started flowing again some decades ago, the initial effluent quality was poor and resulted in highly impaired communities for many years. It wasn't until the past decade that the treatment plants began being upgraded- meaning that recolonization of pollution sensitive species has really only started occurring very recently. In particular, it wasn't until after the treatment plant upgrades that a small, endangered fish- the Gila Topminnow- returned to the Santa Cruz River after extirpation many decades ago.

Recolonization is always a tricky process. So in one section of the river we study near Tucson- it is particularly difficult because of the distances from potential source populations. This portion of the river is isolated from other streams by at least 30 km as the crow flies, and this means that recolonization by aquatic invertebrates, for example, can occur only via long-distance aerial dispersal or by being washed downstream during large, seasonal floods. Roughly 60% of the aquatic invertebrates we've identified here have been in the orders Diptera and Odonata- the true flies and the dragon and damsel flies. Accordingly, these groups are known for their strong dispersal abilities. So, given the Santa Cruz River's isolation and the recent nature of its improved water quality, invertebrate colonization is likely still occurring- in fact we keep finding new species as our long-term monitoring continues.

### **4. Interesting. Does what we know about the Santa Cruz River translate to other rivers that receive treated wastewater?**

**Hamdhani:** I will say what is happening in the Santa Cruz River can tell us that treated wastewater input can facilitate the return of flowing rivers in arid regions, like Tucson, where the water table is currently too deep to support the baseflow. So the source of water is considered as an essential part of river restoration in arid regions. In this case, the degree of water treatment process is a key factor in this restoration. This definitely is not as perfect as a natural river system, but this restoration should be still able to support river services such as recreational, ecological, and educational services that can benefit all riparian and aquatic species and eventually humans. So I think that concept or that reality should be applicable for other rivers

that receive treated wastewater, in particular, in many arid regions and the southwestern United States.

### **5. What's your favorite thing about the Santa Cruz River?**

**Hamdhani:** Hmm, favorite things... Well for me, every time I jump into the river, it's very amazing to see many different kinds of aquatic and riparian species that take advantage of this 'artificial' [in quotations] river flow. This is kind of an animal gathering place where I can see many different kinds of birds, reptiles, frogs, insects, and fish species. Sometimes it makes me forget that I'm in the middle of a desert. It is definitely a beautiful and interesting place to see.

**Drew:** Yeah, so my favorite thing is the unique, interconnected relationship between the river and the people who live here now. So in this strange way, the same population growth and water consumption that was responsible for the river's initial drying is also directly connected to the return of surface water here- through effluent discharge. So although there is an unsettling irony in this relationship, I think it can foster a greater connection between the community and this ecosystem- a sense of appreciation, ownership, and stewardship that can help advance conservation efforts to protect our vulnerable rivers and streams here in the Sonoran Desert.

**Susan:** Thanks so much to Drew and Hamdhani for telling us about the effects of releasing treated wastewater into a dry riverbed. The Santa Cruz River is truly an inspiring place. After decades of water pumping, we found a way to bring a small part of the river back to life, creating a recreational and educational space for the people of Tucson to appreciate the power of water. We should continue to consider our history and indigenous traditional knowledge when making decisions that will affect our waterways so those streams and rivers can persist for future generations to use and enjoy. Thanks so much for listening, this has been Making Waves. I'm Susan Washko. Have a great day!