Multi-tracer characterization of Wildcat Creek in the Berkeley Hills

Emilio Grande [1,2], Jean Moran[1], Pamela Beitz[2]

[1]California State University East Bay, Hayward, Department of Earth and Environmental Sciences

[2]East Bay Regional Parks District, Stewardship, IPM Unit

East Bay Regional Park District — Healthy Parks Healthy People

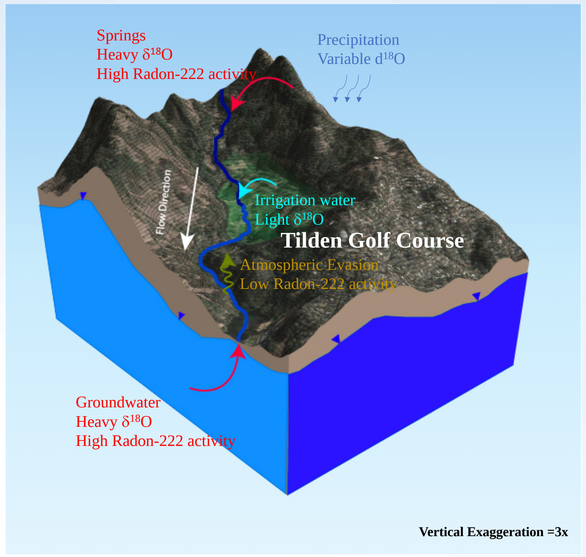
Abstract

Water bodies in the regional parks of the East Bay provide aesthetic value and critical ecosystem services, but are often adversely affected by the activities and infrastructure of the intensely urban environment that surrounds the parks. The East Bay Regional Parks District (EBRPD) leases a golf course in one of its public parks in the Berkeley Hills, Tilden Regional Park. Application of nutrients and herbicides, essential to maintain turf systems, may be transported via surface runoff or through subsurface drainage to surface water, leading to the perception that golf courses are a major contributor to water pollution. We are studying the hydrography of the watershed and the possible contribution of nutrients (NO3–N and PO4–P) transported via storm-generated surface runoff and via groundwater from Tilden Golf Course (TGC) to the primary drainage in the watershed, Wildcat Creek (WC).

We apply isotopic and chemical tracers, including Radon-222 activities and stable isotopes of H_2O, which allow hydrograph separation and examination of surface water-groundwater interaction. Our study is continuing during the rainy season, when high frequency sampling allows in depth analysis of the influences of precipitation on streamflow and subsurface inflow. We are collecting data at a temporal resolution sufficient to calculate transit time distribution using $\delta^{18}O$, so in addition to revealing the fate and transport of fertilizer nitrogen and pesticides/fungicides applied to park features, we will determine the time period over which changes in management practices can be expected to be observed as changes in water quality.

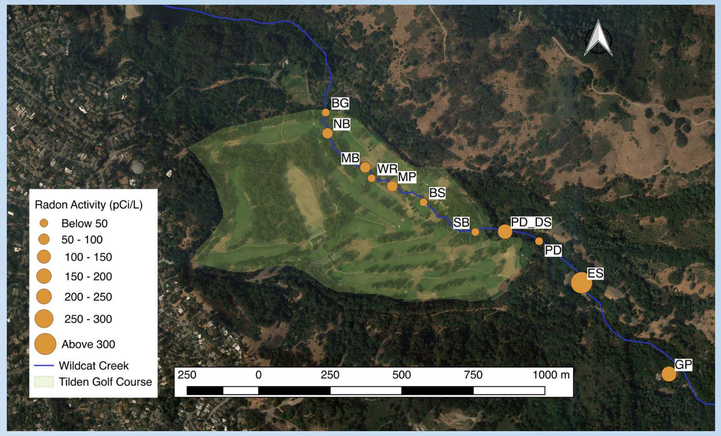
Radon-222

Mixing of different water sources that may contribute variable amounts to the water budget and carry variable contaminant loads can be observed using natural chemical and isotopic tracers. To study the locations and fluxes of groundwater input, we analyzed water samples for radon-222 activity, which has a half-life=3.82 days. Radon is a product of the natural radioactive decay series of ^{238}U and a direct product of alpha disintegration of ^{226}Ra (Bertin and Bourg, 1994). ^{238}U is the most abundant isotope in natural uranium and is found in most rock types (Cecil and Gesell, 1992). However, because of atmospheric evasion, radon activity is low in surface waters downstream of influx locations (Cecil and Green, 2000).



Radon-222 Methodology

Radon samples were collected along Wildcat Creek to determine locations of groundwater influx to the stream. The samples were measured on a RAD7 Radon Detector within a day or two of being collected; the results are then corrected using the decay equation, $A=A_0e^{-\lambda t}$



Location and results of sampling points for Radon-222 along Wildcat Creek. Locations are: Gallespie Spring (GP), Elder Spring (ES), Padre (PD), Padre down Stream (PD_DS), South Bridge (SB), Big Springs (BS), Maple (MP), Weir (WR), Middle Bridge (MB), Carex and North Bridge (NB)

Radon-222 Discussion

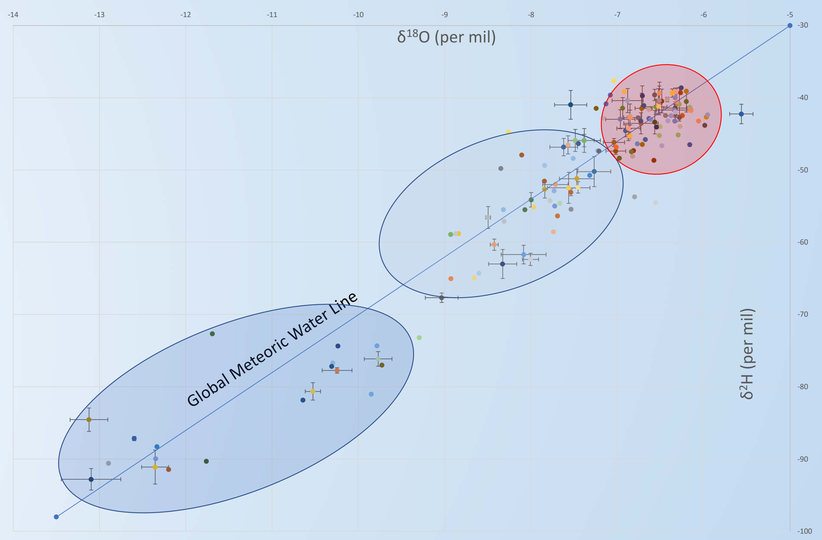
Radon-222 results are plotted on the map above.

- Wildcat Creek has several points of groundwater inflow along the creek, showing gaining, and neutral or losing reaches.
- The two samples ES and GS were taken from springs and their Radon-222 activities represent the groundwater endmember that feeds the stream in the upper reach.
- Knowing the signature of the groundwater allows us to carry out hydrograph separation during the summer months, a process aided by the study of the stable isotopes of water and that will be explained in depth in the next section.

Stable Isotopes as Natural Tracers

Variations in $\delta^{18}O$ and $\delta^{2}H$ values in Wildcat Creek during the dry, summer months of 2017 were used to differentiate locally-derived water from irrigation water on Tilden Golf Course and calculate the effect of irrigation water on the stream.

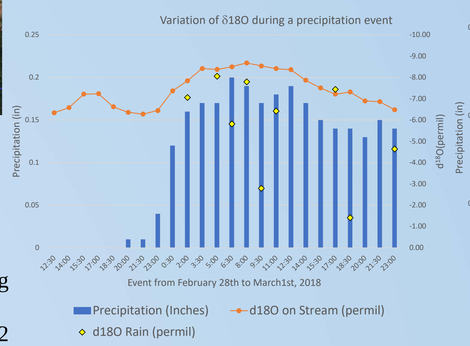
This separation was possible due to the large and constant isotopic signature contrast between natural stream water and (imported) irrigation water.

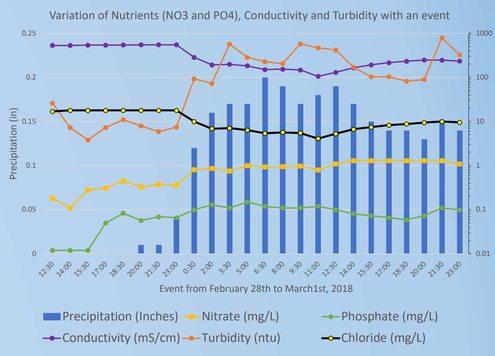


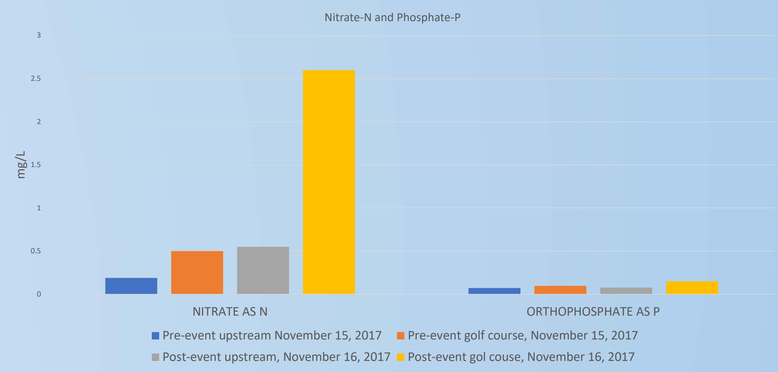
δ18O mixing equations, modified from http://snobear.colorado.edu/Daniel/isotopes/oxygen18.html

Oxygen-18 in mixing model (pre-event)

End Members:
Irrigation water (Q_1), $\delta^{18}O$ = -13.1‰.
Baseflow (upstream of golf course) (Q_2), $\delta^{18}O$ = -6.57‰
Mixed:
Stream Water (Q_{stream}) $\delta^{18}O$ value of -6.93‰
$Q_{stream}=Q_2*(f_A) + Q_1*(1 - f_A)$
$-6.93=-6.57\ f_A - 13.1 + 13.1\ f_A$
$f_A = 0.945$ = 94.5% baseflow in the mix
$f_B = 1- f_A = 1-0.945= 0.055$= 5.5% irrigation water







Preliminary Results

- Rainfall hyetograph is correlated with $\delta^{18}O$ in Wildcat Creek.
  - $\delta^{18}O$ in precipitation is isotopically heavier than stream water during the event.
  - The stream carries a significant component of light, pre-event water, which is likely from groundwater inflow. The isotopic signature of the pre-event water may be affected by isotopically light irrigation water.
- Nitrate increases during the event, but conservative chloride decreases by dilution. Phosphate is tied to turbidity, as it sorbs to particulates.
- In previous sampling campaigns, we have also observed an increase in nutrients between 'natural' upstream background and the golf course, making it likely that turf management results in increased nutrient loads.
- Combined Radon-222, stable isotope, and nutrient concentration results indicate that groundwater, carrying nutrients, is transported to the stream during rain events.

Citations

Bertin, C, & Bourg, Acm. (1994). RN-222 and chloride as natural tracers of the infiltration of river water into an alluvial aquifer in which there is significant river groundwater mixing. *Environmental Science & Technology, 28*(5), 794-798.

Cecil, L.D. & Gesell, T.F. Environ Monit Assess (1992) 20: 55. https://doi-org.proxylib.csueastbay.edu/10.1007/BF00396521. Retrieved on March 11th 2018

Cecil L. D., Green J. R. (2000) Radon-222. In: Cook P.G., Herczeg A. L. (eds) Environmental Tracers in Subsurface Hydrology. Springer, Boston, MA

"Oxygen 18 (18O)." Isotopes, Oxygen 18. University of Colorado Boulder. Nd. Web: http://snobear.colorado.edu/Daniel/isotopes/oxygen18.html. Retrieved on March 12th 2018