SEASHORE PASPALUM: THE OCEAN WATER DILEMMA

Seashore paspalum is highly salt tolerant. Ocean water is the only irrigation water source that is available on the specific site. Just use this cheap and readily available water for irrigation on the golf course or sports field. Is this strategy environmentally sustainable?

ABSOLUTELY NOT!!

Combine the most salt tolerant warm season grass in the world with increasing demands for potable water and a logical conclusion would be to just use ocean water for irrigation of this grass. In theory, that looks good on paper, but common sense has to be factored into this scenario.

One obvious question would be: "How many plants do you see growing on ocean beaches?" The answer is not very many and most of them are woody halophytes or maybe sea oats as a grass. But what about a turfgrass-quality species: can a grass be grown long term with ocean water as the only source of irrigation water, especially with the mowing height requirements and demands for playability and performance that are required on most golf courses?

Seashore paspalum evolved on sand dunes exposed to ocean water for nutrition and ocean water plus rainfall for water requirements. Can you grow pristine turfgrass that is mowed every day at 1/8-inch or 3 mm height-of-cut; then play 150+ rounds of golf daily when irrigating with ocean water? The answer is clearly 'NOT EXACTLY!'

OCEAN WATER QUALITY

How toxic is ocean water? Quite toxic---and every single salt ion in ocean water has an uncanny ability to accumulate in soils if not properly managed. The chart below outlines the total salinity parameters in ocean water as an irrigation water resource.

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ECw = ~54 dS/m   SARw = ~57.4   RSC = <0

TDSw = ~34, 500 ppm (or mg/l) or 28.6 lbs total salt/100 gals (~13 kg/378 L)
or 3886 lbs salt/acre (4351 kg/ha)
or 2135 lbs (968 kg) salt/1000 ft^2 (93 m^2)/acre ft (325,851 gals or 1.233 million L) of water applied to the turfgrass
Sodium = 10,556 ppm (~459 meq/L)
Chloride = 18,980 ppm (~536 meq/L)
Bicarbonates = 146 ppm (~2.4 meq/L)
Calcium = 420 ppm (21 meq/L)
Magnesium = 1304 ppm (~107 meq/L)
Potassium = 390 ppm (10 meq/L)
Sulfates = 2690 ppm (~56 meq/L)

The sodium toxicity and soil profile accumulation issue: sodium is highly toxic, is among the two most difficult salt ions/compounds to try to leach through a soil profile once it has accumulated at concentrations where it becomes a limiting growth factor for turfgrasses (the other includes the bicarbonate complexes involving Ca-P, Ca-Fe, and Na). The only counter ion to excess sodium accumulation in soils and internally within the paspalum plant is available calcium (management is meq/L to meq/L).

With ocean level salinity in irrigation water, you would need to apply 547 lbs (248 kg) calcium per 1000 ft^2 (93 m^2) or 2378 lbs (1079 kg) gypsum per 1000 ft^2 (93 m^2) for each acre-foot (325,851 gals or 1.233 million L) of water applied to the paspalum turfgrass on any site just to counter the toxic concentration of sodium being applied with each irrigation cycle.

You would need to apply 70 lbs (32 kg) lime per 1000 ft^2 (93 m^2) per acre-foot (325,851 gal or 1.233 million L) of water to react with 168 lbs (76 kg) sulfate to form gypsum, in order to stabilize the sulfur additions to the soil profile that can potentially lead to future black-layer problems.

Chloride concentrations in ocean water will normally kill all microbial populations initially, which in turn, affects availability of nutrients in the soil for root absorption. *Nitrosomonas* is shut down and there will be little to no conversion of ammonium-N and urea-N in granular fertilizer products to nitrates when toxic Cl concentrations are applied with each irrigation cycle. Due to the nitrogen concentration in most ocean water sources, you can reduce nitrate additions by 2-3 lbs (0.9-1.4 kg)/1000 ft^2 (93 m^2)/year on the turfgrass.

Since chlorides are highly mobile in soils, you would need to aerate at least weekly on all areas of the golf course in order to leach this salt ion down to the drainage lines. Seashore paspalum has a very high tolerance to chloride concentrations since it was exposed to ~19,000 ppm Cl during evolution, but failure to properly leach chlorides through the soil profile can lead to toxic accumulations in the soil profile and often an increase in localized dry spots on the golf course. Short duration, frequent irrigation cycles can increase that initial ocean level Cl salt and total dissolved soil salt accumulation concentration by 2-16 times higher than the initial 19,000 ppm Cl or initial TDS over a 3-week period. Proper salinity management, including irrigation scheduling and sufficient water volume for flushing the soil profile, is essential for long term survival of paspalum in any turfgrass situation.

Remember also that many areas of the world are experiencing higher salinity levels in ocean water, especially those arid to semi-arid regions where the reject concentrates from reverse osmosis (desalinization) plants are discharged back into the ocean. Therefore, use of 40,000 ppm TDS or 60,000 ppm TDS ocean water is not unrealistic now and in the future. Blending with lower salinity water sources will often be needed to lower the potential salinity impact on the turfgrass ecosystem.

OCEAN WATER INFLUENCE ON TURFGRASS INTERNAL NUTRITIONAL BALANCES

The soil accumulation of salts from ocean water is not the only growth limitation that will impact seashore paspalum. When irrigating with ocean level salinity, many of those soluble salt ions (Na, Mg, Cl, S from sulfates) can potentially foliar-feed directly into the shoots and surface stolons to disrupt nutritional balances at concentrations below nutrient sufficiency levels for the turfgrass. The fertility program for seashore paspalum must be adjusted to account for these salt ion challenges to nutrient balances and imbalances.

The salt tolerance mechanisms in seashore paspalum are genetically regulated via the root absorption system. Paspalum will strictly regulate the uptake of sodium, absorbing (via the roots) the concentration that it needs as a micronutrient, but excluding additional Na uptake once that specific salt ion threshold concentration has been reached internally in the plant.

Sodium is often translocated to vacuoles in the paspalum plant in order to keep the sodium isolated away from the photosynthetic activity. Foliar-absorbed sodium is usually complexed in the wax layer on shoots and stolons, which minimizes entry internally into plant cells. When nutritionally analyzing

paspalum tissue, sodium concentrations will often be quite high if saline/sodic irrigation water is being applied. The high Na concentration is predominately externally localized in the wax layer. If sodium migrates into internal cells and lodges especially in the plasma membrane, that salt ion can reduce growth rates and alter movement of critical nutrients that are required for photosynthesis and turf growth activity.

Because of exposure to high ocean concentrations of magnesium and sulfates during evolution, paspalum did not develop regulatory mechanisms for those two salt ions/compounds. As a result, paspalum is a luxury user of both Mg and SO_4 nutritionally.

Since chlorides are highly mobile internally in the grass plant, that salt ion is rapidly translocated to the ends of the growing points (leaf tips) where it is mowed on a regular basis. Chlorides are also readily mobile in the soil profile, and as long as a regularly scheduled aeration program assists in leaching salts in general, chlorides should not accumulate as they are being recycled from mowed clippings left in the turfgrass canopy to decompose via microbial activity. Occasionally, you may observe leaf tip burn on paspalum shoots early in the morning and prior to mowing the grass. Landscape plants generally are quite susceptible to elevated chloride concentrations in irrigation water.

Magnesium is another high concentration salt ion in ocean water. This nutrient is also a core molecule in chlorophyll and probably because of that function, paspalum did not develop a regulatory mechanism for absorption of that specific salt ion. As a result, paspalum generally is a luxury consumer of Mg in order to sustain essential concentrations needed for chlorophyll regeneration when exposed to ocean level salinity. However, there is a critical requirement for maintaining a delicate balance between calcium and magnesium internally in the paspalum plant in order to sustain expected color expression in the turfgrass. The general rule is to maintain more internal Ca concentrations (>1 meq/L or >% Ca) than Mg (1 meq/L or <%) to achieve the proper shiny, dark green color expression indicative of seashore paspalum cultivars. Therefore, careful proactive monitoring of the Ca and Mg concentrations in plant tissue is recommended regularly to assist in making the necessary site-specific fertility adjustments that are needed to properly balance these two key nutrients in paspalum when irrigating with any level of saline water. Both root absorption and foliar feeding of excess Mg from ocean water or any brackish water that is high in Mg can cause limitations on grass performance, and both sources for Mg accumulation should be closely monitored.

The problems with excess sulfates in ocean water are predominately: (1) soil accumulation of excess sulfates, layering in the soil, lack of adequate and regularly scheduled aeration, sealing above the sulfate layer, and creation of anaerobic conditions in the layer leading to rapid chemical changes from SO_4 to H_2S or hydrogen sulfide, which along with Fe and Mn sulfur combinations can lead to black-layer problems in the soil. The hydrogen sulfide as a gas then kills the root system, (2) foliar absorption of excess sulfur. Paspalum apparently regulates the uptake of sulfur via the root system (which in turn, leaves that excess S to accumulate in soil profile layers) and the turf seems to tolerate the foliar absorption internally in the plant, probably because S is relatively mobile internally in the plant.

FINAL COMMENTS

REPEATED IRRIGATION WITH OCEAN LEVEL SALINITY IS NOT RECOMMENDED AT ANY TIME OR ON ANY SITE, INCLUDING ALL SAND PROFILES. CERTAIN CULTIVARS ACTUALLY HAVE SALT TOLERANCE THRESHOLDS APPROACHING OCEAN LEVEL SALINITY. BUT THE SOIL ACCUMULATION ISSUE AND INABILITY TO ADEQUATELY AND CONSISTENTLY MANAGE EXCESS SALTS ONCE THEY HAVE ACCUMULATED IN A SOIL PROFILE MANDATES THAT OCEAN WATER NOT BE USED ON PASPALUM TURFGRASS IF ENVIRONMENTAL SUSTAINABILITY IS EXPECTED LONG TERM. THE CHART BELOW SUMMARIZES THE VOLUME OF TOTAL SALTS APPLIED WITH EACH IRRIGATION CYCLE OF OCEAN WATER PER ACRE-FOOT AND ACRE-INCH:

TDS (ppm)	Acre-foot/application	Acre-inch/application
	325,851 gals	27,154 gals
34,500	96,680 lbs (43,854 kg)	7776 lbs (3527 kg)
40,000	108,183 lbs (49,072 kg)	9015 lbs (4089 kg)
60,000	162,273 lbs (73,607 kg)	13,523 lbs (6134 kg)

One option in utilizing ocean level total salt concentrations is to blend with lower salinity water sources or reverse-osmosis (desalinated) generated water. The blending options will usually require a 5-10% ocean water vs. 90-95% RO water to provide salinity concentrations that can be turfgrass ecosystem sustainable long term. Irrigation system efficiency and soil infrastructure development will be keys to the sustainability issue.