



BEAR RIVER **ZEOLITE** BRZ™

ODOR CONTROL and AIR FILTRATION*



AGRICULTURE ODORS

Livestock waste, feed and fertilizers.



INDUSTRIAL ODORS

Chemicals, fuels, waste, biohazard fluids, and food processing.



WASTE ODORS

Landfill waste processing and mine effluents.



WATER ODORS

Stock tanks, aquaculture, aquariums, fishponds, septic/sewer systems, and flooded areas.



HOUSEHOLD ODORS

Kitchens, laundry rooms, basements, air conditioners, upholstery, carpets, vehicles, and garbage cans.



PET AND ANIMAL ODORS

Home, artificial grass, veterinary clinics, and kennels.

AGRICULTURE ODORS

To absorb moisture and deodorize waste. The amount of BRZ™ used is dependent on the moisture and nitrogen content of the manure/urea (see table below). Reducing the moisture content with BRZ™ reduces the fly and maggot larvae.

WASTE PRODUCTS

Total Elemental Concentration - Fresh Weight Basis

| Waste Material | Moisture Content (%) | N (lbs/tons) | P (lbs/tons) | K (lbs/tons) |
|---------------------------|----------------------|--------------|--------------|--------------|
| Beef Manure | 85 | 11-30 | 4-14 | 10-40 |
| Dairy Manure | 85 | 10-40 | 6-10 | 8-30 |
| Horse Manure | 80 | 14-30 | 4-14 | 12-16 |
| Poultry Litter (cleanout) | 75 | 20-88 | 29-119 | 3-82 |
| Sheep Manure | 77 | 44-72 | 6-12 | 14-34 |
| Swine Manure | 82 | 8-40 | 10-20 | 8-24 |



COMMON INCLUSION RATES Average Daily Ration (ADR)

| Livestock | ADR/Per Animal |
|----------------------------|----------------|
| Dairy/Beef Cattle | 4-5 oz. |
| Calves | 2 oz. |
| Chickens (Layers/Broilers) | 0.5% |
| Turkeys | 0.6-0.7% |
| Hogs | 1% |
| Sheep | 0.1% |

For odor, fly, and maggot control the following procedures are recommended:

Feed. Animals should be fed from ½ to 2% BRZ™ by weight of the total ration. Feeding BRZ™ is the most economic approach to application used for odor control.

Bedding. Top dress with layers of BRZ™ to reduce odor generation. BRZ™ should be laid down in the bedding or stall areas after clean out. Alternatively, if the clean out cycle is at long intervals, multiple layers of BRZ™ can be top dressed on the manure.

Lagoon. In the case of wash-down operations, the water from the lagoon can be treated to remove the ammonium with a BRZ™ filter column. This will enable the reuse of the wash-down water. BRZ™ can also be an effective air filter for ammonia gas and hydrogen sulfide. BRZ™ loaded with ammonium from the filter and off-gas system can be combined with the manure compost as a fertilizer/soil amendment. The off-gas system can be a floating lagoon cover with attachments to cycle the off-gas through a BRZ™ air filter column. A bio-filter using BRZ is another option to deal with lagoons. A polyethylene foam with geo-textile layer and clinoptilolite cover reduced ammonia gas by 80%.⁶ BRZ™ 14 x 40 mesh or coarser is recommended. Adding 6.25% zeolite to manure slurry by wet weight has been shown to reduce ammonium loss by as much as 55%.

Manure. BRZ™ added to feed captures ammonium during digestion to prevent manure generation of ammonia. The manure from dry operations or the manure sludge from wash-down operations should be composted with 100 to 300 pounds per ton of BRZ™ depending on the nitrogen content. This is generally done in rows where the compost can be turned after temperatures peak. Straw, saw dust, or other sources of carbon must be used with the proper water content to complete the composting process. Composting can take 6 to 10 weeks depending on the efficiency of the operation. BRZ™ 14x40 mesh is preferred.

Anaerobic Digestion. BRZ™ reduces the odor of digestate by holding the nitrogen as ammonium.

Composting. BRZ™ increases the nitrogen content of compost and renders it not soluble in water but plant accessible. The held nitrogen increases the value of compost and mitigates odor.

Fertilizers. Add BRZ™ to fertilizers for potting soils, lawns, crops, trees, shrubs, flowers to reduce odor.

INDUSTRIAL ODORS



Chemicals

BRZ™ will adsorb and mitigate odors from paints, solvents, alcohol, polychlorinated biphenyls (PCBs), possibly methyl tertiary butyl ether (MTBE), diesel, oils, gasoline, urine, acids, bases, antifreeze, chemical and laboratory spills.



Hospitals, Schools and Emergency Services. BRZ™ will adsorb and mitigate odor from vomit, blood, urine, and excrement.



Concrete. Oil and other odoriferous liquids can be removed from concrete floors and other items by the use of -40 mesh BRZ™. Repeat applications and rub it into the surface of the concrete.



Spill Kits for Airports, Vehicles, Aircraft. Sprinkle BRZ™ on the spill and sweep it up.



Slaughter Houses, Rendering Plants, Fish Processing Facilities. Use BRZ™ to manage odor build up in waste collection areas by top dressing waste and by hanging breathable BRZ™ filled bags.



Service Stations, Shops and parking lots. Use BRZ™ for clean up and odor control.

WASTE ODORS



Landfills. Landfills can be top dressed with layers of BRZ™ to reduce odors.



Mine Effluents. BRZ™ is used extensively to prevent the formation of ammonia by removing ammonium from effluents.

WATER ODORS



Stock tanks



Aquaculture

Stock tanks, Aquaculture, Aquariums, Fishponds. Remove algae and ammonium from stock tanks, fish hatcheries, ponds, fish transport trucks and other water sources.

- BRZ™ will adsorb nitrogen (ammonium) before it gases to ammonia.
- Algae are attracted to the held ammonium and will migrate to the BRZ™ resulting in clear water.



Mold and fungus. BRZ™ is an effective desiccant. Moisture held in basements, closets and other damp areas contributes to the growth of mold and fungus and produces musty odors.

- Inhibits the growth of mold (that generate mycotoxins) and fungus in animal feed stuffs, dry distillers grain (DDG), basements, closets, crawl-ways, etc.



Septic, Sewer, Drainfield. A BRZ™ top dress will deodorize flooded areas and absorb moisture.

ODORS IN AND AROUND THE HOME



Kitchens. Use BRZ™ to reduce cooking odors, deodorize refrigerators and freezers, food storage areas, trash storage containers, and to absorb spills on the floors or other areas.



Garbage Cans. BRZ™ can be top dressed or mixed with the waste.



Basements, Bathrooms, Laundry Rooms, Pantries, Nurseries and Closets. Deodorize and absorb moisture in clothes hampers, diaper pails, medicine cabinets, storage areas, closets, suitcases, gym bags, and shoes.

Cars, Trucks, Boats, Aircraft, and RV's. Use BRZ™ to clean spills, and deodorize.

Cigarette Smoke. Place breathable BRZ™ bags in the smoking area and add BRZ™ in ashtrays to minimize odors.

Concrete. Oil and other odoriferous liquids can be removed from concrete floors and other items with -40 mesh BRZ™.

Garages, Driveways. Clean leaks and spills and deodorize with BRZ™.

Air Conditioning Filters. A breathable bag with BRZ™ located behind air filters will help deodorize.

PET AND ANIMAL ODORS



Artificial grass infill. Use 1 to 4 pounds per square foot of BRZ™ to lower pet and other odors.



Carpets, Mattresses, and Upholstery. To deodorize, dampen item and apply -40 mesh BRZ for 12-24 hours until dry, and remove with vacuum cleaner.



For cages, kennels, litter boxes as a clumping litter, or as an additive for other litters.

AIR FILTRATION^{1, 2, 3, 5, 7, 8, *}

(with numbered extraction methods)

AMMONIA GAS (NH₃) **1** To remove ammonia gas from CAFOs, farms, rendering plants, landfills, sewage plants, lagoons, waste water plants, and mine explosive gases.

Physiological Response to Various Concentrations of Ammonia ⁷

| Physiological Response | Approximate Ammonia Concentration in Air (ppm) |
|---|--|
| Least detectable odor | 50 |
| Maximum concentration allowable for prolonged exposure | 100 |
| Maximum concentration allowable for short exposure (1/2-1 hr) | 300-500 |
| Least amount causing immediate irritation to throat | 400 |
| Least amount causing immediate irritation to eyes | 700 |
| Compulsive coughing and possible death | 1700 |
| Dangerous for even short exposure (1/2 hr) | 2500-4500 |

CARBON DIOXIDE (CO₂) **5** This is the green house gas that has allegedly caused global warming.

CARBON MONOXIDE (CO) **5** This gas is lethal in the higher concentrations and it is emitted from incomplete combustion of fuels in coal fired generators, and engines of all types.

ETHYLENE (C₂H₄) **5** "Ethylene gas acts as a plant hormone that accelerates respiration leading to maturity and softening and ripening of many kinds of fruits... yellowing of green vegetables, and may be responsible for many post-harvest defects in fruits and vegetables."⁴ To extend shelf-life and keep an acceptable visual quality, accumulation of ethylene in the packaging should be prevented. This is accomplished by adding BRZ™ in breathable small bags or by other methods.

EXHAUST GASES (NO_x, N₂O, N, SO₂, CO₂, CO) **8** Exhaust gases are the most important contaminants to the atmosphere. "The use of clinoptilolite and a noble metal reduced exhaust gases by 19.7 to 75% depending on the contact time."

HYDROGEN SULFIDE (H₂S). **3**, **4** and **5** To remove hydrogen sulfide from oil refineries, natural gas plants, well heads, and tanks.

METHANE GAS (CH₄) **5** Nitrogen is removed from natural gas to increase the BTUs.

MERCURY (Hg) **5** Mercury is extremely toxic and can be lethal. "Mercury can be removed from exhaust gases of an industrial process (coal fired generators, etc.) or combustion processes by the use of clinoptilolite that acts as a sorbent. The mercury-laden sorbent can be regenerated by heating it to at least 400°C to remove the mercury."⁸

NITROGEN (N) **5** Nitrogen can be removed from contaminated natural gas (methane) that reduces the fuel heating value. Fifteen percent of the US natural gas is off grade.

NITROUS OXIDES (NO_x, N₂O, NO₂) **8** "Nitrous oxides are the most frequently monitored components of the atmosphere"⁵, and they are primarily the result of burning fossil fuels and automotive engines. Nitrous oxides damage the ozone layer and contribute to the greenhouse effect. The long-term effects of higher concentrations of nitrous oxide are that they decrease the resistance of organisms to infection and together with sulfur dioxide contribute to the development of long term chronic inflammatory disease of the respiratory track. Clinoptilolite alone can be used to decrease the nitrous oxides. More often it is used as a sorbent together with a noble metal such as platinum, palladium or rhodium.

RADON (Rn²²²) AND ITS DAUGHTER ELEMENTS **1** and **5** Radon gas is a daughter element of radium (which can be removed by clinoptilolite) and a serious carcinogen if breathed for long periods of time. It is commonly found in basements from the decay of underlying bedrock. Although clinoptilolite will adsorb radon a much higher efficiency is achieved by exchanging silver into the clinoptilolite that makes it a catalytic scrubber.

OXYGEN (O₂) **5** Oxygen can be enriched by the removal of nitrogen with a pressure swing apparatus (PSA).

SMOKE DEODORIZER **5** For houses, apartments, commercial buildings.

SULFUR DIOXIDE (SO₂), **3** and **5** To remove and concentrate sulfur dioxide streams to produce liquefied sulfur dioxide, elemental sulfur, sulfuric acid, or ammonium sulfate (a fertilizer).

VOLATILE ORGANIC COMPOUNDS (VOCs) **2** To remove benzene, toluene, ethyl benzene, and xylene (BTEX) from produced water.

EXTRACTION METHODS^{1, 2, 4, 3, 5, 7, 8, *}

PRODUCT 3/8" x 1/4", 4 x 8, 8 X 14, 8 x 40, 14 x 4, and various other screen sizes

1 CATION EXCHANGE. "Zeolite" refers to a group of minerals that are basically hydrated calcium potassium sodium aluminosilicates in which the water is held in cavities and in the lattice. The lattices are negatively charged and they loosely hold cations such as calcium, sodium, ammonium, and potassium and also water. Their ability to exchange one cation for another is known as their "cation-exchange capacity" or "CEC." Cation-exchange capacity is a measure of the number of cations per unit weight available for exchange, usually expressed as mill equivalents per 100 grams of material. One of the major causes of odor from animals is the generation of ammonia from urea and manure. Essential advantages of using zeolite for odor control are that it captures ammonia and prevents the formation of ammonia gas that is lighter than air and is the aerosol for noxious odors. It also removes moisture that inhibits mold, bacteria, and musty odors, and it prevents the leaching of the nitrogen to the groundwater.

2 SURFACE MODIFIED ZEOLITE (SMZ). In other systems, the zeolite in the air filter is surface modified to become an anion exchange element. The modifier is typically a quaternary amine. Some applications have involved a revolving filter that adsorbs in one position and desorbs in another position with hot air. Most of the SMZ can be regenerated for further use.

3 IMPREGNATION WITH OXIDANT. Potassium permanganate can be impregnated in BRZ. As air passes through a filter, the hydrogen sulfide is oxidized to sulfur dioxide. A further addition would be metallic iron that would precipitate the sulfur as pyrite or marcasite completely removing sulfur from the air stream.

4 INOCULATION WITH BACTERIA. BRZ is inoculated with bacteria to restart sewage treatment plants to resume the digestion process after thermal or chemical shock. It becomes a carrier and can be used for a variety of applications, i.e. petroleum eating bacteria, hydrogen sulfide, etc. Microorganisms colonize in the BRZ where they get nutrients and water.

5 SORPTION BY MOLECULAR SIEVE OR SEQUESTRATION.

The crystal structure of clinoptilolite contains channel ways or windows that allow the passage of air through the mineral. These cages will capture and hold certain size molecules. BRZ™ becomes a molecular sieve to exclude various amounts of other molecules larger than 0.28 nm. However, BRZ will pass a certain percentage of molecules that are greater than 0.28 nm through different crystal axis orientations.

Pore spaces of BRZ™
Two lattice sizes for each crystal orientation

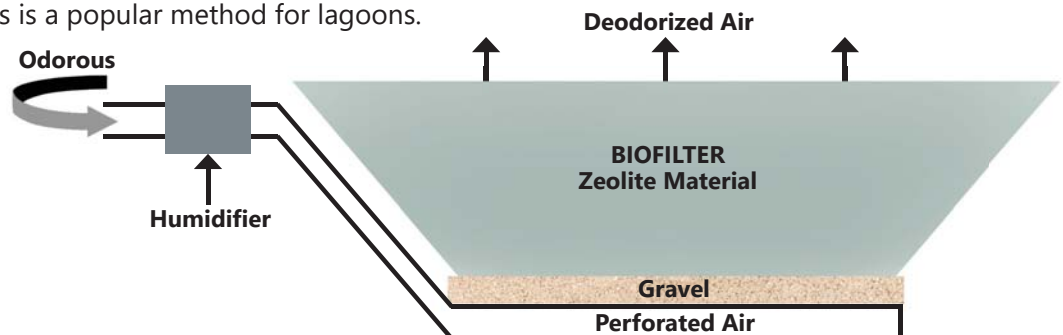
| Crystal Axis | Orientation 1 (nm) | Orientation 2 (nm) |
|--------------|--------------------|--------------------|
| 001 | 0.76 | 0.30 |
| 100 and 102 | 0.47 | 0.28 |
| 001 | 0.46 | 0.36 |

Kinetic Diameter of Molecules⁵

| Molecule | Kinetic diameter nanometers (nm) |
|------------------|----------------------------------|
| CO | 0.376 |
| N ₂ | 0.364 |
| NO | 0.317 |
| O ₂ | 0.346 |
| N ₂ O | 0.33 |
| H ₂ O | 0.265 |
| SO ₂ | 0.36 |
| CO ₂ | 0.33 |
| NH ₃ | 0.36 |
| CH ₄ | 0.4 |

In a typical zeolite filter air is passed through a bed of zeolite and it retains the impurities. These filters can consist of a layer of zeolite held between screen layers. Alternatively, they can be non-woven polyester impregnated with finely ground zeolite. The sequestered gas can be desorbed by heating, washing, exposing to sunlight, or by a pressure swing apparatus (PSA), temperature swing apparatus (TSA), or an electric swing apparatus (ESW) so that the BRZ™ can be reused for long periods of time.

6 "BIOFILTER". In another system commonly known as a "biofilter" the gas to be purified is passed through a bed of zeolite that contains various bacteria. The temperature, moisture, and nutrients must be controlled. Here the gas is consumed by the bacteria. This is a popular method for lagoons.

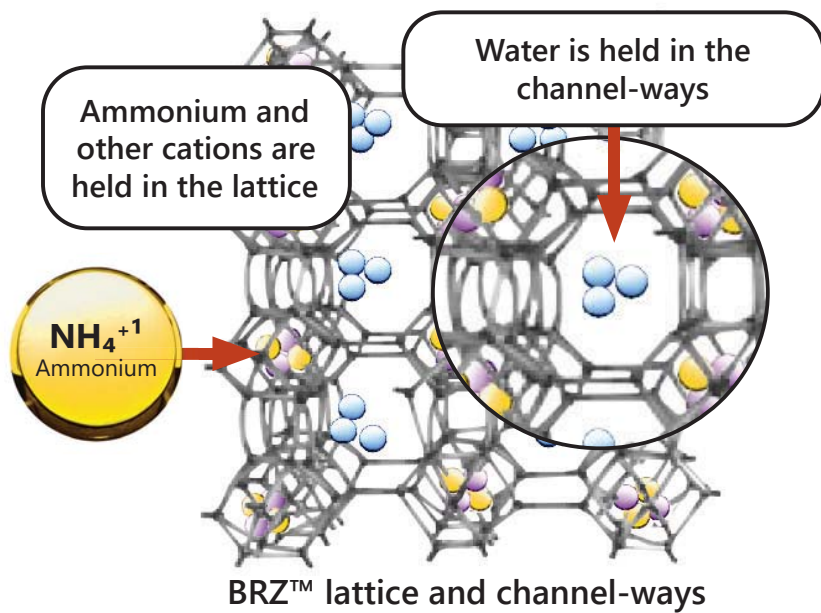


7 "SILVER IMPREGNATION." Clinoptilolite is impregnated with silver ions (commonly silver nitrate solution). It captures the radon by cation exchange (Method 1) and the sorbent can be regenerated by heating. The daughter elements of radon are not in the gas form but will stay in the clinoptilolite.

8 "CATALYTIC CONVERSION." Clinoptilolite is used as a sorbent in conjunction with a noble metal usually platinum, palladium, or rhodium to form a catalytic scrubber for nitrous oxides that can be regenerated by raising the heat.

Bear River Zeolite BRZ™ is a naturally occurring volcanic rock that contains clinoptilolite.*

The clinoptilolite lattices are negatively charged and are able to hold positive ions, such as ammonium, calcium, sodium, and potassium. The held cations are not water soluble.



Dry BRZ™



Wet BRZ™

ENVIRONMENTALLY FRIENDLY*

- California Proposition 65 compliant (no crystalline silica, a known carcinogen)
- No heavy metals
- Eliminates fertilizing with toxic chemicals
- **GRAS (Generally Regarded as Safe)** anti-caking agent under CFR Title 21, Sec. 182.2729.
- **FDA and CFIA Approved** for use as a flow/anti-caking agent in livestock feed at up to 2%.



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* Additional information on file at Bear River Zeolite Co.