

Connecting the Namib Sand Sea, the Stars, and the Universe

The Namib Sand Sea extends from south of the Kuiseb River to just north of Lüderitz, and from the base of the escarpment in the east right up to the Atlantic in the west. It spans a surface area of some 34,000 square kilometers. One of its many striking features is the extensive dune belts, home to many a fascinating feature and creature, and the sheer endlessness of its ever-changing light and scenery. And as every traveler will soon notice, there is sand, lots and lots of it. But how much actually? The famous astronomer Carl Sagan once said that *"the total number of stars in the universe is greater than all the grains of sand on all the beaches of the planet Earth"*. But how many grains of sand are actually found in the Namib Sand Sea? Let's investigate!

Before we use the numbers, let us first get to grips with the really big ones. We estimate the quantity of sand in the Namib Sand Sea to be a whopping 10^{12} cubic meters. That is a 1 followed by 12 zeros, or one million million ($1 \times 10^6 \times 10^6$), or one thousand billion¹ ($1 \times 10^3 \times 10^9$), or 1,000,000,000,000! Most of us do not readily appreciate the sheer size of such a number. So let us start using numbers we can all still appreciate: take a teaspoon and scoop up some Namib sand, remembering that a standard teaspoon holds approximately 5 ml, which is 5 cubic centimeters. Then pour out 4/5 of it, and you end up having approximately one cubic centimeter of sand, i.e. the volume of a cube similar to a small dice with a width, length and height of one centimeter each. Now let us look at individual grains of sand: the size of the sand grains found in the Namib Sand Sea varies considerably, but if we measure a few we find that grains of 0.2 millimeters in diameter are quite common. For the time being we therefore assume that all the grains of sand we have just scooped up are of such a size. Then putting 5 such grains next to one another makes one millimeter, which implies that 50 grains are needed - all neatly stacked one next to the other - if we want to have a string of sand grains one centimeter long. This implies that in one cubic centimeter, you will find approximately $50 \times 50 \times 50 = 125,000$ grains, or slightly more than one-hundred thousand or 10^5 sand particles, for now ignoring the fact that sand does not stack exactly like that in a cube. In one cubic meter, that is a cube with a length, width and height of one meter each, has one million cubic centimeters, one could therefore stack away some one million times 10^5 grains of sand. That is 10^{11} grains per cubic meter, or 100 billion sand particles (100×10^9). Staggering, but what does it mean?

Actually, there are a lot of 'billions' around us: the world has a population of between 6 and 7 billion people, Namibia's gross domestic product (GDP) for 2008 / 2009 is expected to almost reach N\$ 60 billion, nationally we will spend N\$ 4.7 billion on education in the financial year 2008 / 2009, and Namibians consumed approximately 3.5 billion units of electricity (kWh) in 2006, and NASA had a budget of some N\$ 137 billion to "reach the stars" in 2007. Using our one-cubic meter cube filled with Namib sand, the billions actually become quite easy to visualize: if you want to get an idea of how much 7 billion is, you would look at only the top 7-centimeter layer of the sand cube, and when digging your hand into it, you'd get a feeling for what an awful lot of sand grains you are dealing with and how much 7 billion actually is. If you would like to know how many one dollar coins make up our Namibian GDP, you'd take the top 60 centimeters of our cube. That's a lot of sand, and of course, a lot of dollar coins needed to total N\$ 60 billion. So the idea of a cube of Namib sand, to visualize the staggering numbers we often speak about, is a handy tool. The number story gets even more fun, though...

¹ Here we use the American definition of a billion, i.e. 1,000,000,000, or 10^9 .

A most fascinating time in the Namib Sand Sea is around sunset. It is not only because you may be sitting on a dune, enjoying a traditional Namibian sundowner, but you'll also be mesmerized by the variety and fresh splendor of colors that the Namib offers. It is also, that one by one, the stars above you become visible, and remind us that we are just a tiny speck in this magnificent Universe of ours. We are reminded that with the unaided eye, you can only see a few thousand stars, while at the same time we know that our Solar System is embedded in a gigantic galaxy that is home to some 100 billion stars. But that is interesting: one cubic meter of Namib sand holds approximately the same number of grains of sand as stars we find in our galaxy! That makes it easy to remember!

If we have 10^{12} cubic meters of sand in the Namib Sand Sea, and every single cubic meter is home to some 10^{11} grains of sand, then the total Sand Sea volume contains some $10^{12} \times 10^{11} = 10^{23}$ grains of sand in total. That is a huge number, a number we can truly call *astronomical*! Let us see what the Universe has to offer: the Hubble Space Telescope has for years photographed the most distant parts of our universe. No one ever actually counted the number of galaxies in our Universe, but the Hubble data allows us to make some estimates. And because we want to have fun with the numbers rather than being very accurate, let us make some estimates too: from the small patches of the universe that Hubble has surveyed, we can extrapolate that the number of galaxies over the whole sky is - be amazed - of the order of 100 billion, or 10^{11} galaxies. Truly astounding! Our numbers do not satisfy any accounting rigor, but so what? Now we can compute the number of stars in the Universe. Just multiply the number of stars per galaxy by the number of galaxies in the Universe, and you get $10^{11} \times 10^{11} = 10^{22}$, or 10,000 billion billion.

Now hang on. Did we not say that the number of grains of sand in the Namib Sand Sea is approximately 10^{23} ? Yes we did. This implies that there are about ten times more grains of sand in the Namib Sand Sea than there are stars in the Universe. But then we made many assumptions while computing the above, and so we should not be too concerned whether the above numbers are identical, or a factor of ten or so smaller, or larger. The fact remains, we have just connected the grainy splendor of the Namib Sand Sea with the twinkly magnificence of the stars, and the Universe we inhabit. We have a first feeling for the real big numbers around us, those truly astronomical numbers that we use to quantify our awe of the heavens, and those mesmerizing facts we find right here on Earth too. In fact, right in the Namib.

So next time you visit the Namib and get to see the grandeur of its dunes, think about it: there are about ten times as many cubic meters of sand in the Namib Sand Sea than there are grains of sand in every cubic meter. And in every cubic meter of Namib sand you have approximately the same number of grains than you have stars in our galaxy, and more or less the same numbers of grains of sand as there are galaxies in the Universe! So have another look at the Namib, have the soft sand trickle through your fingers, be in awe at its beauty, be tempted to start counting the grains, and be amazed how these small grains connect us so readily to our cosmic home. And feel inspired and liberated by the countless grainy and twinkly marvels that nature so readily makes available to us all.