that is, $$R \sim (t^*)^{\mu_s} \quad (2)$$

with $$\mu_s = 1/D_d = 1/3 \quad (3)$$

Here $$t^* \sim U^{*1/2} \Delta p D_{12}\, t \quad (4)$$

and $$U^* = U(\nu D^2{}_{12})^{-1/3} \quad (5)$$

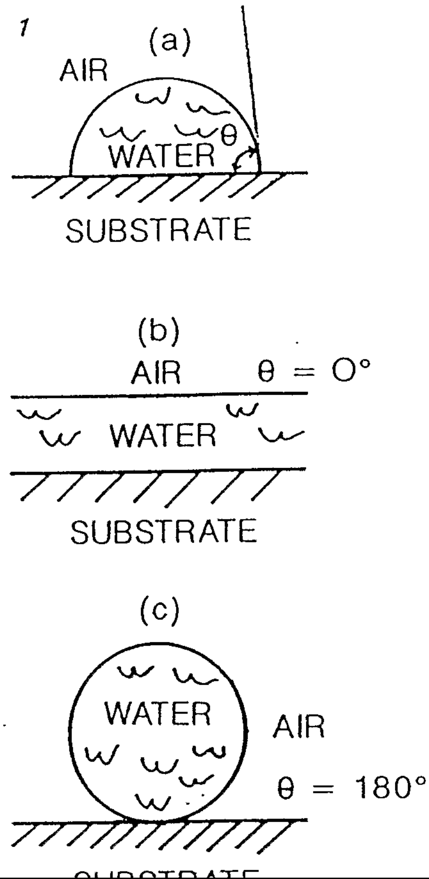
with ν the kinematic viscosity of air.

When the velocity U is small (quiet air), the boundary layer becomes very large

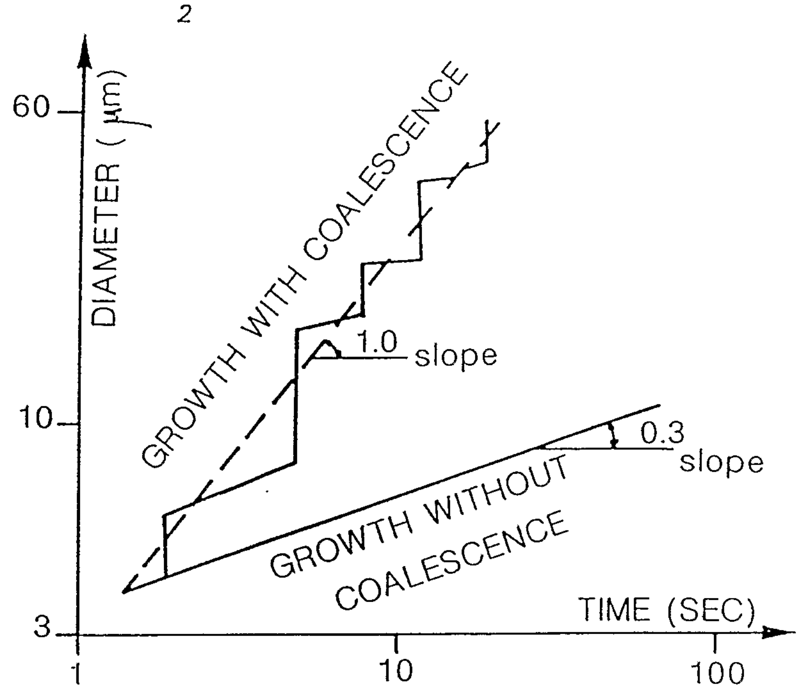
the new drop is approximatively at the barycenter of the two "parents". This has the interesting properties of leaving room on the substrate for further condensation and growth, as shown by the surface coverage of the new droplet, equal to $2^{2/3}\pi R^2$, to be compared to $2\pi R^2$ (case of two "parents" of same radius).

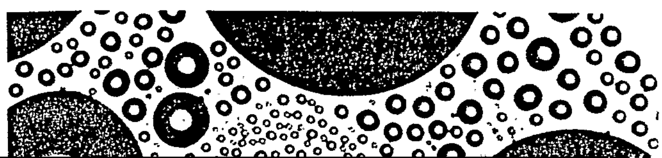
Several stages of growth can be characterized, depending on the interactions between the droplets, the

1


(a)
AIR
θ
WATER
SUBSTRATE
(b)
AIR
θ = O°
WATER
SUBSTRATE
(c)
WATER
AIR
θ = 180°

2


DIAMETER (μm)
60
10
3
GROWTH WITH COALESCENCE
1.0 slope
0.3 slope
GROWTH WITHOUT COALESCENCE
TIME (SEC)
1
10
100



radius $\langle R(t^*_j)\rangle$ (pattern at t^*_j) and $\langle R(t^*_i)\rangle$ (pattern at t^*_i). See figure 3.

The time dependence of $\langle R\rangle$ can be shown to be (Beysens et al. 1991; Beysens and Knobler, 1992):

$$\langle R\rangle \sim (t^*)^{\mu_a} \qquad (8)$$

with $\mu_s = \mu_a \cdot (D_d)/(D_d - D_s)$ (9)

Here D_d is the droplet dimensionality (=3), and D_s is the substrate dimensionality. For the usual situation where the substrate is a plane, $D_s=2$ and

$$\mu_s = 3\,,\ \mu_a = 1 \qquad (10)$$

The growth is then considerably accelerated by coalescence (Figure 2).

Appearance of new "families" of droplets

Depending on the experimental conditions, new tiny droplets can nucleate in the space left free after a coalescence. These droplets form a new "family", which exhibits all the features (growth laws, surface coverage) of the first generation of droplets. After a while the substrate is covered by a whole range of "families" (Figure 4). Although the surface coverage exhibits the same (universal) value for each family, the total surface coverage is seen to increase and ultimately reaches unity.

Effects of the substrate heterogeneity

The stages 2 and 3 are often altered because the substrate is not perfect. The chemical and geometrical heterogeneities have the effect of pinning down the perimeter of the drops. The drop that results from the coalescence of two drops is no longer hemispherical, instead it is cigar shaped. The surface left free does not compensate for the growth; the surface coverage is seen to continuously increase; interconnected droplet structures form, leading to pseudo-wetting film.

Gravity effects. Steady state

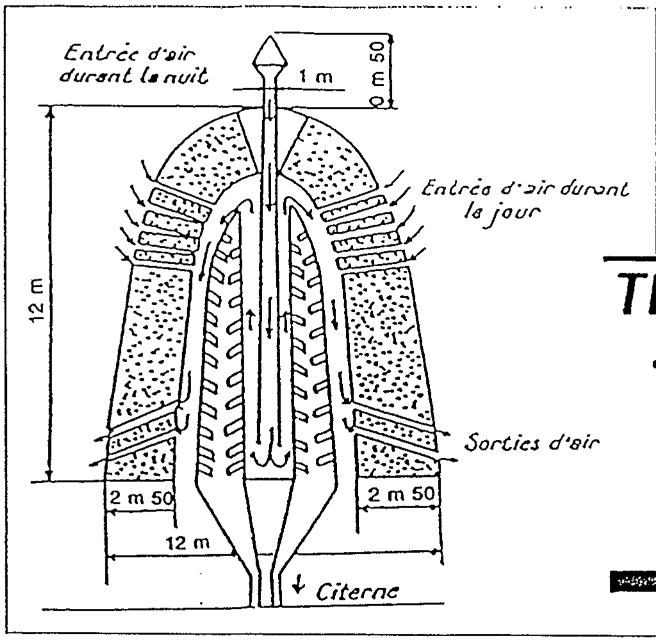
Gravity causes the largest drops to flatten end eventually flow, which has the merit of cleaning the surface and enables a new generation of droplets to nucleate. A steady state can thus be reached, with the continuous formation of new droplet patterns and the flow of the largest drops.

It must be noted that to any condensation process corresponds also a thermal release in the substrate. The heat generated by condensation has to be evacuated so that the process does not stop by itself. The humidity and temperature (vapor pressure) of the ambiant air has also to be maintained at the desired level. Dew formation on vegetation can be effective in the open air from sunset to sunrise because cooling is ensured by radiation effects (Lhomme and Jimenez, 1992). In contrast, dew formation is most effective on massive structures in the morning because of conduction and inertial effects. These remarks introduce the following section, devoted to a number of attempts to extract humidity from atmosphere.

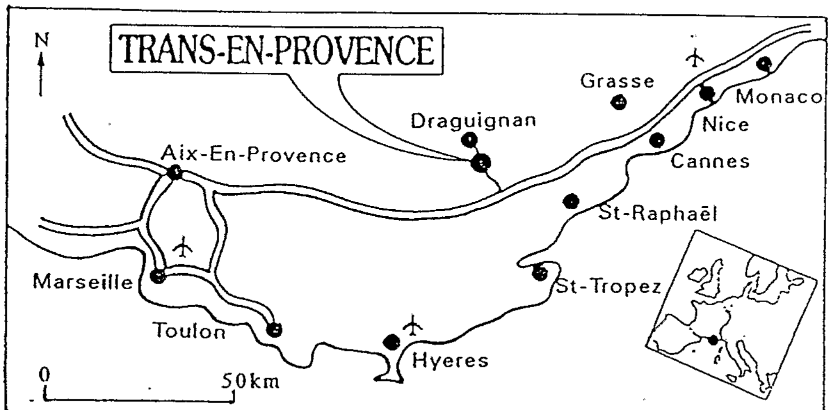
Drought, dew and atmospheric wells

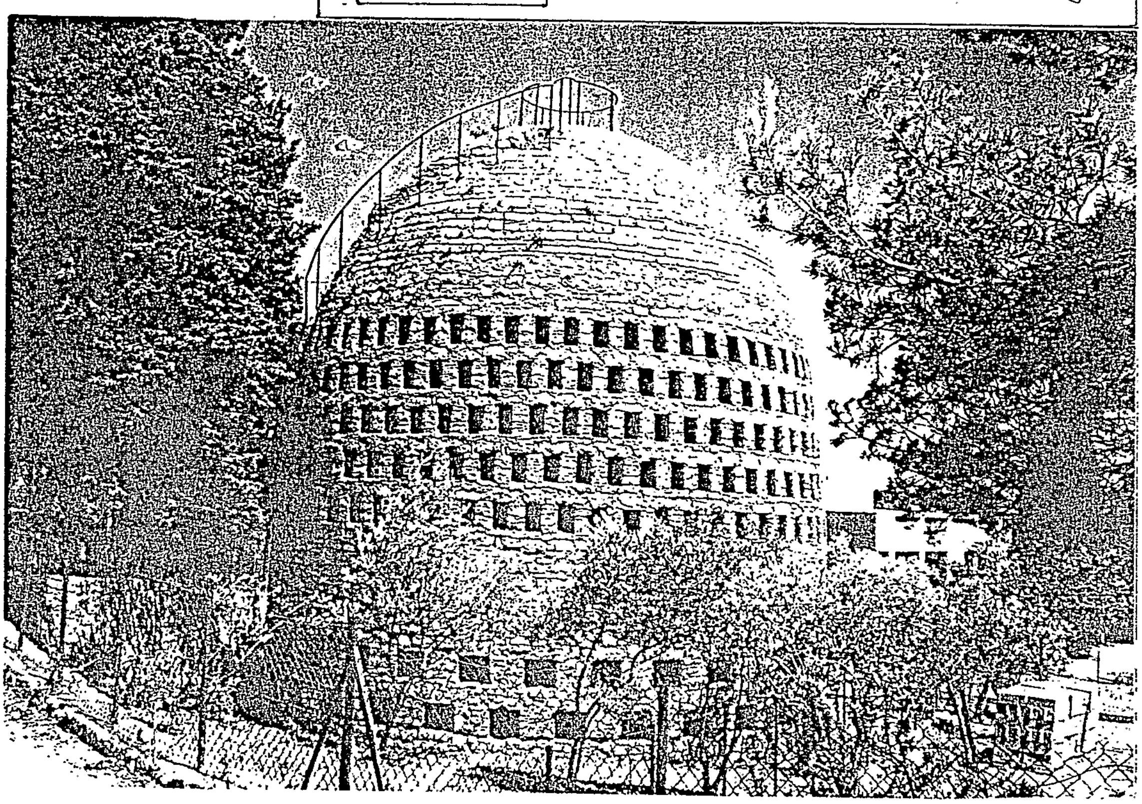
Discovery of Theodosia dew-catchers

An antique supply channel network without any spring was discovered almost at the beginning of the 20th century, above Féodosiya (previously, Theodosia) a city of 60,000 inhabitants on the Black Sea Coast (Crimea, Ukraine). Féodosiya is 100 km east of Yalta. In antiquity, Theodosia was a colony founded by the Greeks in ~600 B.C. and destroyed by the barbarians (IIIth century A.D.). It was one of the flourishing Grecian colonies of which the most famous city was Ponticapée (nowadays, Kerch, Crimea, Ukraine). During water supply works in a drought period, the discovery of huge stone heaps at the head of the network led the russian engineer Zibold to the conclusion that it was possible to rebuild a natural water collector, a so-called atmospheric well, to catch dew. Works were stopped by the Soviet Revolution but Hitier (1925) presented the russian trials at the French Academy of Agriculture and the project continued in Southern France.



Figures 5. The Trans atmospheric well. Location, photography and cross-section.





French atmospheric wells

L. Chaptal, head of the Bioclimatological Station in Montpellier (Hérault), made further trials using a small pyramid (3 m x 3 m x 2.32 m). The maximum daily discharge was 2.5 litres in summer (Chaptal, 1932).

Trials continued in the thirties in Trans-en-Provence (Var), a small city (Figures 5). A construction (12 m high and 12 m in diameter) was built by A. Knapen, a belgian engineer (Chaptal, 1932). In fact, the prelimary project was to build two atmospheric wells in Algeria where the temperature difference between night and day is higher than in Southern France. To buy building-plots was rather complicated in Algeria, while on the other hand A. Knapen had bought land in Trans. The Trans dew-catcher never produced high quantities of water, but it is now unique worldwide and hence preserved and restored under the authority of J.-P. Portheret, mayor of the city (Gioda and Acosta Baladón, 1991; Acosta Baladón, 1992) (Figures 5).

Other trials through the World

Studies performed on dew by Chaptal were well-known because the *Organisation Météorologique Internationale*, the previous name of WMO before the Second World War, admitted their quality (Damagnez, 1958). Following Chaptal's example scientists proposed to build large dew-catchers in Lybia (Sensidoni, 1945), and in Mauritania (Masson, 1948). However Reis F. Cunha (1964) was the only one who succeeded, by building a small stone wall on Cape Verde Is. The wall (2.5 m x 1.0 m x 1.8 m) which was installed on Serra Malegueta (Santiago) had a waterproof basement. It never produced dew water and indeed it could only produce fog water in this mountanious and oceanic climate.

Conclusions

Dew is a neglected water resource and all the trials with large dew-catchers which were performed in the 20th century were unsuccessful. However, dew-catcher apparatus produce up to one litre.day^{-1} and may be useful in individual survival equipments.

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