Tree damages in the vicinity of mobile phone base stations

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Abstract: Since 2005, on the occasion of medical examinations of sick residents living near mobile phone base stations, changes in nearby trees (crown, leaves, trunk, branches, growth) were observed at the same time as clinical symptoms in humans occurred. Both deciduous and coniferous trees as well as shrub species were affected. The assessment of tree diseases is neither impeded by psychological impacts nor by change of location.
Impacts of radiofrequency electromagnetic fields (RF-EMF) from radar, radio and TV on plant life have been scientifically demonstrated over the past 80 years. Since 2005, the influence of modulated RF-EMF - that are used in mobile phone telephony - has been investigated in lab experiments. Several research groups reported about the impacts on germination, growth and cell metabolism. Only a few scientific papers have been published to date on research concerning the health conditions of trees in the vicinity of mobile phone base stations. These papers are indicating harmful impacts.
For this reason, between 2007 and 2013, the status of trees standing in the neighbourhood of 620 mobile phone base stations was documented. In the radio shadow of buildings or that one of other trees, the trees stayed healthy. However, within the radiation field, damages were observed on exposed trees. Additionally, unilateral crown damage, beginning on the side facing the antenna, strongly indicates a causal relationship with RF-EMF. In the following, examples of crown damages and of premature colouring of leaves are presented. The authors believe, that scientific research is urgently needed to examine these observations.

Keywords: *Mobile phone base station, radiofrequency electromagnetic fields (RF-EMF), tree damage*

Introduction

On the occasion of medical examinations of sick residents living near mobile phone base stations, it was often surprising, from 2005, that trees fell ill in the same surroundings simultaneously with humans (WALDMANN-SELSAM 2007).
During a workshop of the German Federal Office for Radiation Protection (BfS) on “Health effects of electromagnetic fields from mobile phone telephony - medical reports” on 2nd of .August 2006 not only six physicians presented exemplary diseases of people exposed to RF-EMF, but also the physicist and electrical engineer Dr.-Ing. V. Schorpp demonstrated damage patterns which indicated a causal relationship between tree damages and chronic RF-EMF exposure (BFS 2006, SCHORPP 2006; recent summary of his findings: 2011).
From 2004, Municipal gardeners in the Netherlands documented rapidly increasing, new and unexplainable patterns of damage. A contribution of RF-EMF was discussed (BOOMAANTASTINGEN 2013). As it became apparent that especially after UMTS starting tree damages increased with high speed at all the mobile phone base stations visited, affected trees have been documented then too.
In November 2007 the BfS refused scientific investigations: “As to potential effects of RF-EMF on plants there are no clear indications from scientists up to now. That's why I do not attach priority to this question either.” (DEHOS 2007).
The reference book “Dendrology and Tree care” (“Baumkunde und Baumpflege” in German) of Dipl. hort. Dr. phil. nat. Aloys Bernatzky from 1994 and further publications out of eight decades verify however, that the statement of the BfS is not supported by the actual state of scientific documentation (BERNATZKY 1994, WALDMANN-SELSAM 2010).

Material and Methods

There are 55 mobile phone sites in Bamberg with a total of 445 sector antennas and 6 omnidirectional antennas (March 2011). In the EMF database of German Federal Network Agency actual information about the mobile phone sites can be found (Bundesnetzagentur 2013). The site certificate ("Standortbescheinigung") provides information on mounting height of the antennas, the number and main beam direction of the sector antennas, number of omnidirectional antennas (ND), number of other transmitters, as well as the horizontal and vertical safety distances (see Tab. 1). The issue date of the current certificate only indicates the recent state of site expansion, but does not show its temporal upgrading in the past. The date of the initial start of the mobile phone base station has to be asked for from municipal authorities or the residents.

Standortbescheinigungs-Nr.: 671501 Datum der Erteilung: 09.07.2010

Sendeantenne	Montagehöhe über Grund (m)	Hauptstrahlrichtung (HSR) in °	Sicherheitsabstand in HSR (m)	Vertikaler Sicherheitsabstand (m)
Mobilfunk	18.4	10,000	5.00	0.84
Mobilfunk	18.4	10,000	5.13	1.45
Mobilfunk	18.4	130,000	5.00	0.84
Mobilfunk	18.4	130,000	5.13	1.45
Mobilfunk	18.4	250,000	5.00	0.84
Mobilfunk	18.4	250,000	5.13	1.45
Mobilfunk	18.4	100,000	5.08	0.96
Mobilfunk	18.4	100,000	5.08	0.96
Mobilfunk	18.4	190,000	4.52	0.70
Mobilfunk	18.4	190,000	5.23	1.51
Mobilfunk	18.4	270,000	5.23	1.51
Mobilfunk	18.4	270,000	4.52	0.70

Tab. 1: Example: Mobile phone site Schranne 3, Landesvermessungsamt, in Bamberg: On this base station are currently twelve sector antennas installed (Bundesnetzagentur 2013).

The sites of all the mobile phone base stations and the main beam directions of the sector antennas were marked in the map of Bamberg (Fig. 1).

From 2006 the state of some striking trees was recorded photographically (first digital camera Olympus FE-100). Since 2007 the condition of trees around most base stations in Bamberg have been documented in time series. These pictures were taken with the digital camera Panasonic DMC-FZ50.
At some base stations the radiofrequency electromagnetic fields (RF-EMF) were measured. The measurements were carried out with the EMF-broadband analyzer HF 59B (27 MHz – 3.300 MHz), UBB27_G3, from Gigahertz Solutions (measurement of the sum, peak values of power flux density).
The emission of sector antennas takes place in main and side beams, bundled vertically and horizontally. In general, a sector antenna covers a sector of 120 °. The RF-EMF are reflected by buildings (Fig. 2) and hills, diffracted on edges. Both buildings and trees attenuate the radiation. This leads to an inhomogeneous RF-field.

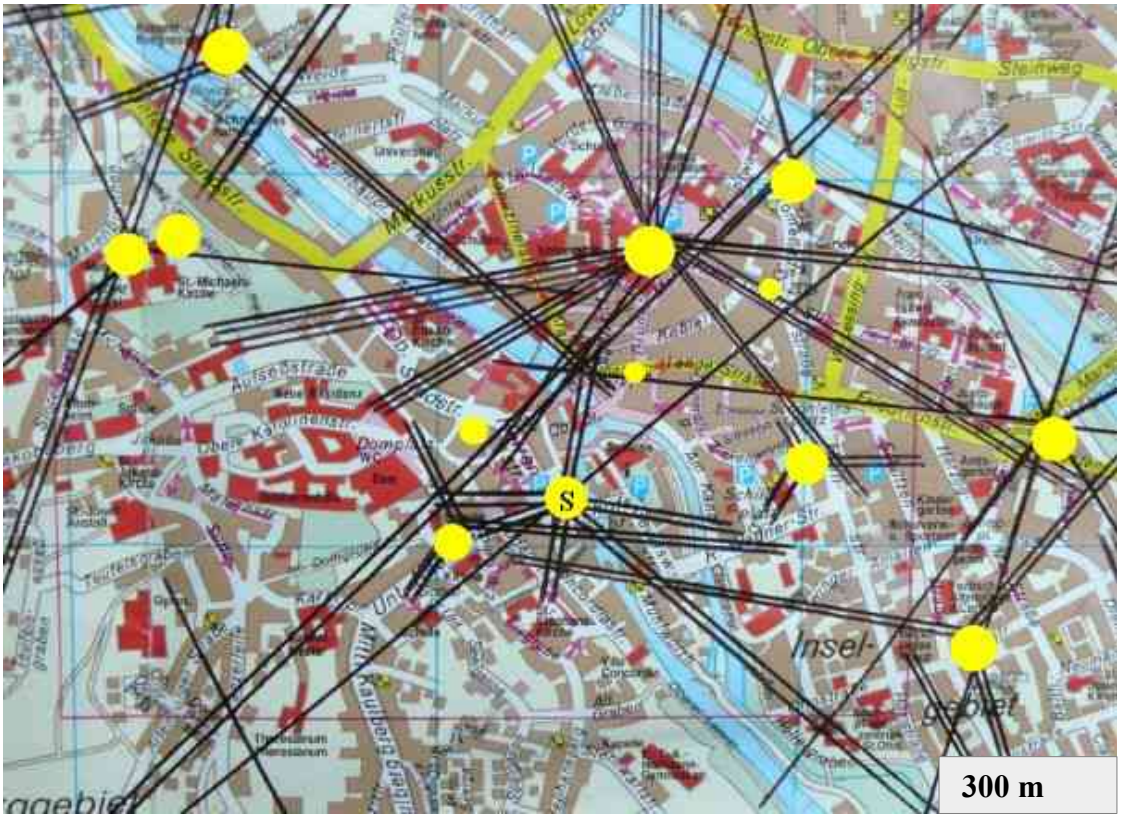


Fig.1: Detail from Bamberg city map with Domberg, Michelsberg, Concert Hall, Center, Schranne (S), Wilhelmsplatz and a part of the Haingebiet. The sites of the mobile phone base stations (yellow) and the main beam directions of the sector antennas (black) were added (base of the map: City map Bamberg, 23. edition, Städte-Verlag E. v. Wagner & J. Mitterhuber).

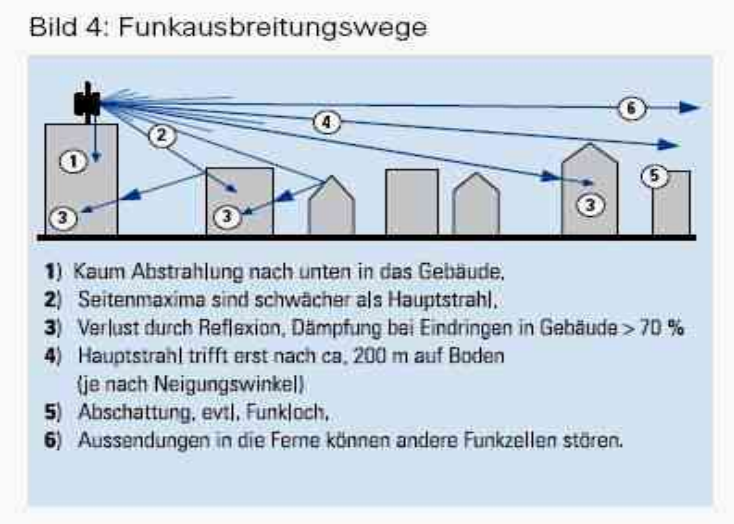


Fig. 2: Paths of distribution of RF-EMF. The graph shows at point 5) that buildings shield from radiation (from Bavarian State Ministry for the Environment and Health, StMUGV 2007, Figure 4)
1) Only little radiation downwards into the building.
2) Side beams are weaker than main beam.
3) Loss through reflection, attenuation at penetrating buildings > 70%.
4) Main beam hits the ground after about 200 m (depending on inclination angle).
5) Attenuation, eventually dead spot.
6) Long-distance radiation can interfere with other radio cells.

Examples

A. Documentation of tree damage in time series

Spruce trees and birch, Bamberg, Zollnerstraße

Since 2008 tree damages were observed in the three main beam directions of the mobile phone base station at Zollnerstraße. Two spruce trees and a birch are growing in a front garden while exposed to the radiation field of two 215 °- sector antennas. In May 2010, the spruce, which was closer to the station, lost many needles in the upper part. The birch did not grow upwards (Fig. 3a). Within the next three years the loss of needles increased (Fig. 3 b).

Fig. 3a: 27 May 2010: Two spruce trees and a birch in the radiation field of the mobile phone base station Zollnerstraße in Bamberg in May 2010. The spruce facing the transmitter has lost many needles in the upper part. The birch does not grow upwards (Photo: C. Waldmann-Selsam).

Fig. 3b: 28 June 2013: Over a period of three years the needle loss of the spruce to the right has increased (Photo: C. Waldmann-Selsam).

Maple, Bamberg, Hauptsmoorstraße

In June 2008 it was striking that a maple in a front garden in Hauptsmoorstraße in Bamberg presented its left side heavily damaged and already trimmed (Fig. 4a). The right side was normal. Visual contact was given from the maple to the mobile phone base station Hauptsmoorstr. 26 a with its 18 sector antennas (Fig. 4c). The distance is 280 m. In the following time the damage increased. In June 2010 leaves on the left and at the top showed brown leaf margins. Due to the asymmetrical shape of the crown, road safety was no longer guaranteed. In winter 2010/2011 the tree was felled (Fig. 4b).

Fig. 4a: 8 July 2008: Unilaterally damaged and already trimmed maple with visual contact to the base station Hauptsmoorstr. 26 a in Bamberg (Photo: C. Waldmann-Selsam).
Fig. 4b: 3 June 2011: As the damage increased, the maple was felled in winter 2010/2011 (Photo: C. Waldmann-Selsam).

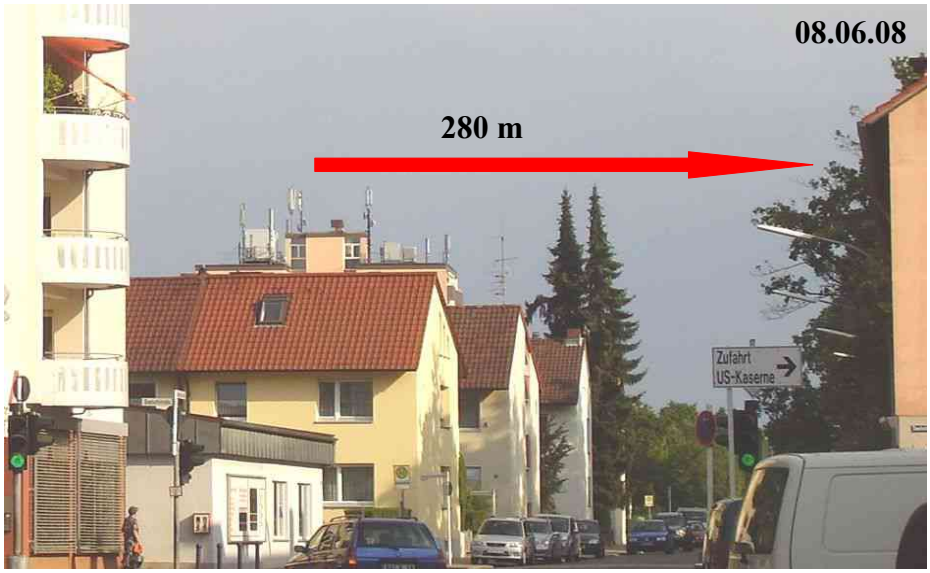


Fig. 4c: 8 June 2008: View from the crossing Hauptsmoorstraße/ Seehofstraße on damaged maple to the right, mobile phone base station Hauptsmoorstr. 26 a and two conifer trees with growth disturbance on the top (Photo. C. Waldmann-Selsam).

Around this mobile phone site, numerous damages of garden trees were observed and documented since 2008. They began often at the side which was facing the antennas. All existing trees were affected: pear, cherry, walnut, birch, lime, beech, oak, hornbeam, field maple, arborvitae, yew, sugarloaf spruce and various conifers. Only in the radio shadow of buildings one could see healthy trees.
The spruce, birch and maple trees serve as examples for hundreds of documented, inhomogeneous damaged treetops in the town and the district of Bamberg. Hundreds of trees had to be felled in Bamberg over the last five years. At all tree species, this kind of damage had occurred. Soil compaction, soil sealing, salt, diseases, pests, drought or climate change could not explain why trees became ill unilaterally, why trees die though standing in parks and near the water, why leaves become brown in June or why, at some places, the Virginia creeper turned red already in July.
It was noted that the damaged trees had visual contact to mobile phone base stations and that trees in the radio shadow of buildings or other trees did not show such a damage.
These observations led to the hypothesis that there is a relationship between the EMF- emissions of the mobile phone base stations and the unusual damage patterns in trees rapidly increasing in recent years. To test this hypothesis measurements of the RF-EMF were carried out at damaged trees and at Virginia creeper..

B. Relation to RF-EMF-Exposure

Maple, Bamberg, railway station

Since July 2008 the one-sided damage and browning of a maple at the railway station of Bamberg was documented. The maple grows on a grass verge in the middle of the asphalt-covered parking space. To the southern and to the west there is visual contact to mobile phone base stations. On 30 May 2012 measurements were carried out on the south and northeast side of the tree at a height of three meters. The power flux density was 970 µW/m² on the damaged and brown south side, and 130 µW/m² on the healthy and green northeast side (Fig. 5).

Fig. 5: 26 June 2012: One-sided damaged maple tree on a grass verge at the parking of the railway station in Bamberg. There is visual contact (to south and west) to mobile phone base stations. The measurements in a height of 3 meters showed considerable differences between the south and the northeast side: south side 970 µW/m², northeast side 130 µW/m² (Photo: C. Waldmann-Selsam).

Four maple trees on a meadow, Bamberg, Gutenbergstraße

On a meadow in Gutenbergstraße, four maple trees are standing side by side. From 2007 the considerable difference between the trees was striking. Maple tree 1 had no crown, but shoots from its trunk. At maple tree 2 and 3, the crown development was disturbed. Maple 4 had a round, leafy crown (Fig. 6). This different development continued in the following four years. From maple 1 one can see the mobile phone site Gutenbergstr. 20. From maple 4 the mobile phone site is invisible because of the diagonal situated building in between. On 27 November 2010 RF-EMF measurements were carried out. At maple 1, the power flux density was 560 µW/m², at maple 4 50 µW/m². After four years, in July 2012, the striking differences between the four maple trees still exist.

Fig. 6: 29 August 2008: Four maple trees on a meadow along the Gutenbergstraße show considerable differences in August 2008. There is visual contact to the mobile phone site Gutenbergstr. 20 from maple 1 whereas from maple 4 there is no visual contact. Measurements on 27 November 2010: 560 µW/m² at maple 1, 50 µW/m² at maple 4 (Photo: C. Waldmann-Selsam).

Maple and hornbeam, Bamberg, Upper bridge

On the north side of the Upper bridge, which is leading to the Old Town Hall, a maple and a hornbeam are growing on a narrow islet between the Regnitz river and the Ludwig-Danube-Main canal. Mid-October 2009 both trees still had dense foliage (Fig. 7a). In the following period maple and hornbeam became more and more transparent (Fig. 7b, 7c). The hornbeam already coloured yellow in August. Branches died. In spring 2012, dead branches were removed. Maple and hornbeam are located in the radiation field of the mobile phone base station Schranne 3 (land surveying office) on the former Franciscan monastery (s. map Fig. 1 and site certificate Tab. 1).
From the Upper brigde one has an unobstructed view southwards to the mobile phone base station. The distance is 134 m. The mobile phone base station started operating in 2005 and was enlarged in the following years. In 2011 there were twelve sector antennas (2x 10 °, 2x 100 °, 130 ° 2x, 2x 190 °, 250 ° 2x, 2x 270 °) in a mounting height of 18.4 m . The main beam of the two 10 °- antennas hits the bridge. The upper half of the hornbeam, which is located in the RF- field of the base station is transparent. The lower half, which is shielded by the stone bridge pier against the EMF- emissions, shows normal foliage. On 24 May 2012 results of the measurements were: about 8000 µW/m² on the bridge, about 200 µW/m² 30 cm below the railing and 30 µW/m² at the canal (Fig. 7d).

Fig. 7a: 13 October 2009: View from the south to maple and hornbeam trees at the Upper bridge in Bamberg with dense foliage (Photo: C. Waldmann-Selsam).

Fig. 7b: 4 October 2011: Conspicuous crown transparency and the beginning of crown dryness (Photo: C. Waldmann-Selsam).

Fig. 7c: 12 July 2012: After removal of dead branches in spring 2012, the crowns show many gaps (Photo: C. Waldmann-Selsam).

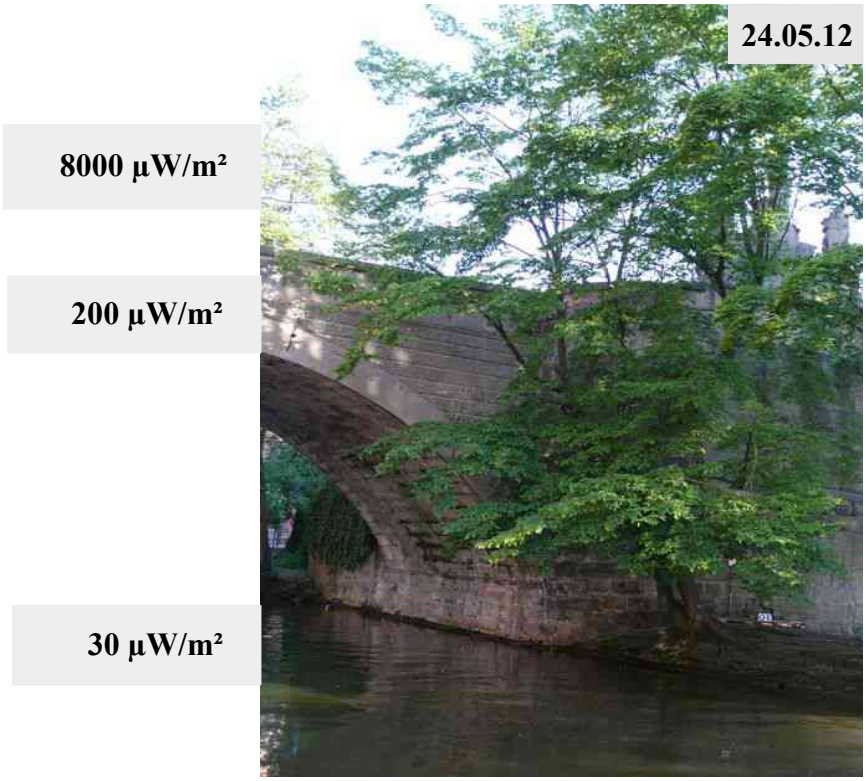


Fig. 7d: 24 May 2012: View from the north to the Upper bridge, the hornbeam and a part of the maple. The upper half of the hornbeam, which is located in the radiation field of the mobile phone base station, is transparent. The lower half, which is shielded by the stone bridge pier against the EMF- emissions, shows normal foliage. On 24 May 2012 results of the measurements: about 8000 µW/m² on the bridge, about 200 µW/m² 30 cm below the railing and 30 µW/m² at the canal (Photo: C. Waldmann-Selsam).

Virginia creeper, Munich, Botanical Institute

The south facade of the Botanical Institute is densely overgrown with Virginia creeper (Fig. 8a). On the north facade large areas of the Virginia creeper died off at the eastern and western wing (Fig. 8b). The remaining virginia creeper was coloured red in great parts already on 3rd of August, 2012. From the north facade the mobile phone site on the Eichamt is visible with 30 sector antennas at a distance of 210 m.
The power flux density was 4980 µW/m² on the north side, 10 µW/m² on the south side. Around the Eichamt there is a large number of damaged trees: for example near the hospital Dritter Orden and in the RF-exposed parts of the Botanical Gardens.

Figure 8a: 3 August 2012: South facade of the Botanical Institute of the Ludwig Maximilian University in Munich with dense vegetation of Virginia creeper. Result of the measurement: 10 µW/m² (Photo: C. Waldmann-Selsam).

Figure 8b: 3 August 2012: Western wing of the north facade of the Botanical Institute with partially dead and prematurely red coloured Virginia creeper. RF-EMF from the mobile phone site Eichamt in a distance of 210 m hit upon the north facade and are reflected. Result of the measurement: 4980 µW/m² (Photo: C. Waldmann-Selsam).

Discussion

Heat, frost, drought, as well as composition, compaction and sealing of the soil, road salts, air and soil pollutants, diseases and pests affect the health of trees. Until now, the possibility that radiofrequency electromagnetic fields (RF-EMF) have an impact on the health of trees, has not been taken into account in the differential diagnosis. The factors commonly considered are not sufficient to explain the tree damages presented above.

The following observations point to a possible link between RF-EMF and tree damage:

1. In the electromagnetic field of **all** mobile phone base stations visited numerous tree damages were observed.

2. The damage occurred in temporal relation with the putting into operation of new mobile phone base stations.

3. Woody plants of all species are affected (deciduous and coniferous trees as well as shrubs).

4. In the radio shadow of buildings or trees, however, one could find healthy trees at the same time, often only a few metres away. They should also suffer from air pollutants, ozone pollution or climate change, if these factors were the cause for the tree damage at this place.

5. Trees growing in open areas as gardens and parks and at lakes and rivers (sectionally) are affected. Soil compaction, soil sealing, pollution, road salts or drought cannot explain these damages at such sites.

6. Trees in alleys and in rows are often damaged variously. The different exposure by bundled radiation of sector antennas (beams) can explain this phenomenon.

7. Crown damage often starts inhomogeneous (for example on the side that faces an antenna, or only in the upper part where visual contact to a mobile phone base station is given).
If no one-sided root injury due to construction or small scale pathogenic soil differences is present, experts do not have a plausible explanation for this special crown geometry of damaged trees. The attenuation of the RF-EMF within the treetop offers an explanation. A part of the RF-EMF is absorbed by leaves or needles, a part is reflected, scattered and diffracted. RF-EMF measurements on damaged and on healthy crown sides showed great differences, thus confirming the shielding by leaves or needles.

8. Leaves change colour prematurely and fall already in summer. Frequently, browning starts at the leaf margins. Since this change occurs also in gardens, it cannot be caused by road salt. The scientifically, repeatedly proven influence of RF-EMF on plant metabolism can cause premature colouring and premature leaf fall (BEAUBOIS et al. 2007, GOLDSWORTHY 2006, ROUX et al. 2006, 2008, SHARMA et al. 2009, TKALEC et al. 2009, VIAN et al. 2006).

9. At some sites trunks and branches show longitudinal bark fissures or stripes. It may be the result of excessive growth. Scientific studies verified that certain frequencies and pulse sequences can promote growth (MURAJI et al. 1998). In addition, unusual bulbs occurred at trunks of various tree species under RF-EMF-exposure. Such extraordinary changes at tree stems, observed in Alphen aan de Rjin, led to investigations at the University of Wageningen (VAN LAMMEREN and VAN KUIK 2007).

10. The increased growth of fungi, algae, lichens (symbiosis of fungi and algae) and mosses is

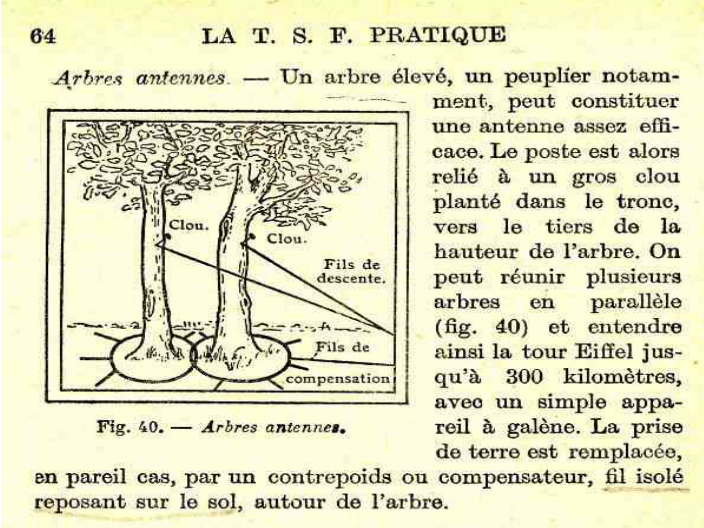
observed not only on trees, but also on fences, benches, roofs and sculptures. That's why the reason for the increase cannot lie just in the affected trees. Extensive test series of Bortels reported already in the 1950ies that the growth of fungi was influenced by natural electromagnetic impulse radiation of the atmosphere (sferics) (BORTELS 1951). The increase of lichens even near busy roads shows that there must be other factors promoting the growth of lichens except clean air.

11. The rapidly increasing damage patterns were observed in many countries since 2004. There is a temporal relationship between the building-up of the UMTS network and the acceleration of tree damage.

Scientific studies and observations of communication technicians found effects on plants from electromagnetic fields since 80 years (WALDMANN-SELSAM 2010).
Some selected examples are presented below.

Poplars as receiving antennas

The French manual "La T.S.F. Pratique" from 1924 stated that a high poplar tree represents a good receiving antenna for radio waves. The poplar tree enabled radio reception from the Eiffel tower 300 km away (COUSTET and WEISS 1924).



64 LA T. S. F. PRATIQUE

Arbres antennes. — Un arbre élevé, un peuplier notamment, peut constituer une antenne assez efficace. Le poste est alors relié à un gros clou planté dans le tronc, vers le tiers de la hauteur de l'arbre. On peut réunir plusieurs arbres en parallèle (fig. 40) et entendre ainsi la tour Eiffel jusqu'à 300 kilomètres, avec un simple appareil à galène. La prise de terre est remplacée, en pareil cas, par un contrepoids ou compensateur, fil isolé reposant sur le sol, autour de l'arbre.

Fig. 40. — *Arbres antennes.*

Fig. 9: Poplar trees as receiving antennas for radio waves (from: COUSTET and WEISS 1924: 64).

Biological effects of radiowaves

Around 1950 Brauer, Harte and Kiepenheuer examined the biological effects of meter waves (wavelength 1.5 m) on plants at the Institute for Forest Botany at the University of Freiburg. The results are of tremendous importance but little known. Investigations of the growth by division in the Broad Bean (Vicia faba) showed that extremely weak field strength significantly increases the division frequency whereas higher field strength reduces the division frequency. There was no temperature increase, so that an athermal cell physiological effect had been found under weakest field strengths (BRAUER 1950, Kiepenheuer et al. 1949).
Studies on the effect on meiosis in pollen mother cells of the evening primrose (Oenothera) found that meter waves at low field strength (1.5 V/m) and a short exposure time (15 min) represent a strong mutation trigger: "On the whole, in 220 analyzable cells 29 certain chromosomal mutations were found. (...) The detection of the mutagenic effect of VHF is of special theoretical importance for the mutation research because this radiation with its low quantum energy has effects which

cannot be explained by strand breaks. The mutagenic effect of VHF is also of considerable importance because this radiation occurs in nature temporarily in strengths where induction of mutations have to be expected. Considering the great expansion of VHF for radio and television broadcasting the practical relevance of these results is that one has to expect severe damage of plants around transmitters. As to the actual occurrence, there are already observations of so-called VHF-forest aisles near directional antennas and of dying plants near TV-transmitters." (HARTE 1950; translated from German).
In 1972 Harte, professor at the Institute of Developmental Physiology, University of Cologne, published the results of field research in cooperation with the NDR (North German Broadcasting): Induction of chromosome mutations by radiowaves in pollen mother cells of Oenothera. Inflorescences of Oenothera with young flower buds were irradiated with radiowaves. One series of experiments was done with short treatments (1h, 4h, and 12 h) of λ=1.50 m; another serie with treatment of the plants during the whole vegetation period. In pollen mother cells at the state of diakinesis a great number of chromosomal mutants, fragmentations as well as recombinations, were found. The results were in accordance with earlier experiments on the mutagenic action of short radiowaves. The mutagenic effects occured upon application of a relatively low field strength (HARTE 1972).

Tree damage by radiofrequency electromagnetic fields

In 1981, severe forest damage arose, especially on mountain ridges and often far away from sources of pollution affecting fir, spruce, pine and beech trees simultaneously within a short time. Forest botanists as well as electrical and telecommunications engineers endowed with electrophysiological knowledge searched for the cause.
In 1983, Engineer K. Ermer, Bayreuth, fenced damaged, brown-coloured spruce trees with a wire mesh. Afterwards the spruce trees turned green again (BERNATZKY 1994, ERMER 1989, PLATTHAUS1985).
Dipl.-Ing. H. Hommel, Fraunhofer Institute ICT, Pfinztal, published measurements of field strength in the altitudes and carried out measurements of the electrical conductivity of fir needles. From the observed changes in the conductivity as a function of frequency, field strength and the seasons, he drew conclusions about the electric action on membranes (HOMMEL and KÄS 1985, HOMMEL 1985, 1986 a, b).
At the Symposium “New hypotheses on causes“ (“Neue Ursachen-Hypothesen”), organized by the Federal Environment Agency (Umweltbundesamt) in 1985, he insistently demanded measurements of the field strength distribution in areas where forest damage occurred, investigations about the change of the conductivity on conifers throughout the year and research on the effects of radio frequency electromagnetic fields on plant metabolism.
In 1988 and 1989 Dr.-Ing. W. Volkrodt, electrical engineer and physicist, documented the forest damage at 32 locations near directional radio, radar, radio and television transmitters. His poster at the “International Congress on Forest Damage Research”, Friedrichshafen, in1989 (“Internationaler Kongress Waldschadensforschung”), showed the devastating consequences at Ochsenkopf and Schneeberg (Fichtelgebirge), Wurmberg (Harz) and Wasserkuppe (Rhön) as well as the dense network of microwave radio links in Bavaria (VOLKRODT 1987, 1991).
Looking for the causes of dying forest syndrome (“Waldsterben”), Prof. Dr. W. Koch, Chair of Forest Botany of the University of Munich, carried out a long-term experiment (1985-1988) "comparing clean air/ site air at spruce" in the anterior Bavarian Forest (KOCH 1989). He could not recognize any difference between the branches that had been exposed to clean air and those prone to air of the natural site. From his observations, he concluded that other causes than air pollution had to play a role.
Nevertheless, Dr. Riesenhuber, Minister for Research and Technology, refused investigations as is said in a letter to Dr.-Ing. Volkrodt dated 28th of February 1990: "Even after receiving your latest letter the Federal Minister for Research and Technology does not see any reason to launch a large-

scale research program on the effects of non-ionizing radiation on our forests" (RIESENHUBER 1990; translated from German).
Dipl. hort. Dr. phil. nat. Aloys Bernatzky, garden architect, expert on tree care and nature conservation, a pioneer of urban ecology, observed and documented crown damage occurring on the side facing the antennas, disturbances of growth of conifers rising above the roof ridge as well as the parallel existence of exposed, damaged and shielded, healthy trees (BERNATZKY 1986). In the reference book from 1994 “Dendrology and Tree care” (“Baumkunde und Baumpflege”) he published the current research reports, observations of Ermer and the following diagram (Fig. 10) (BERNATZKY 1994).

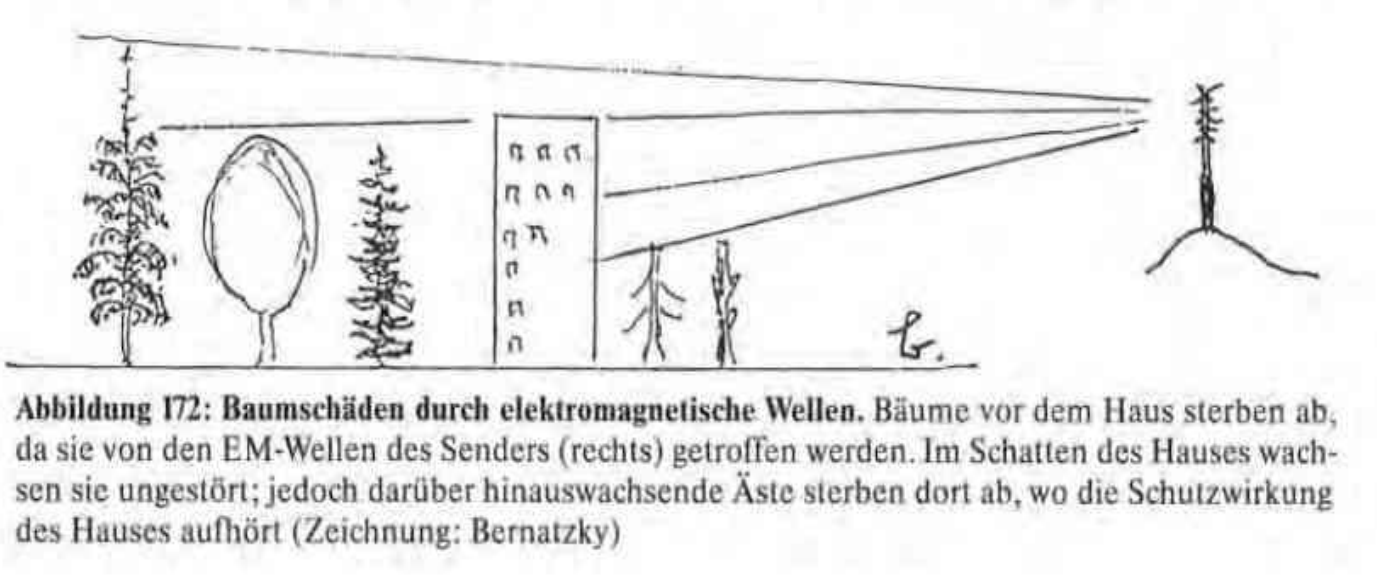


Abbildung 172: Baumschäden durch elektromagnetische Wellen. Bäume vor dem Haus sterben ab, da sie von den EM-Wellen des Senders (rechts) getroffen werden. Im Schatten des Hauses wachsen sie ungestört; jedoch darüber hinauswachsende Äste sterben dort ab, wo die Schutzwirkung des Hauses aufhört (Zeichnung: Bernatzky)

Fig. 10: Tree damage by electromagnetic waves. Trees in front of the house die, because they are hit from the electromagnetic waves of the transmitter (on the right). In the shadow of the house they grow without disturbance.; but branches, which grow up higher than the building, die where the protective effect of the house ends (from BERNATZKY 1994: 216)

Balodis et al. proved in 1996 that the growth of pines was inhibited after the Skrunda radar station had begun to operate in 1970: At 29 sites the growth of the trees was analyzed retrospectively for the period 1959 until 1988 on the basis of the annual growth rings. The annual growth of the pines was reduced in all exposed areas (BALODIS et al. 1996, KALNINS et al. 1996).
Selga found radiation-related cellular dysfunction around the Skrunda radar station and nonspecific stress reactions, which led among other to accelerated resin production and accelerated aging of the pines (SELGA and SELGA 1996).
Lerchl et al. (Universities of Wuppertal and Karlsruhe) examined one-year old seedlings of three conifer species (total number 451). In the period from October 1999 to May 2000 (222 days), the plants were exposed to a frequency of 383 MHz (pulsed; in accordance with the TETRA signal). As a result, growth acceleration as well as lowering of the ratio of chlorophyll a / b was observed in Pinus pumila. In all three conifer species, the number of dead plants had significantly increased in the exposed groups (Lerchl et al. 2000).
In the discussion it says: "Despite marginally altered growth due to exposure, the physiology of exposed conifers seems to be negatively influenced by exposure to EMF at 383 MHz, causing a decline in the photosynthetic system which may be the first indication of a decline in the plant's overall status.” Until now the complete study with all results has not been published, contrary to the announcement from 9 January 2007 (LERCHL 2007). Only an abstract is available (LERCHL et al. 2000).

Table 3: Numbers of dead plants after exposure for 222 days. *, $p<0.05$ (χ^2-test)

Species	Control	Exposed
Pinus pumila	6.0 %	20.4% *
Abies alba	17.9%	38.4% *
Abies grandis	6.7%	16.3% *

Tab. 2: Number of dead plants after 222 days of exposure (LERCHL et al. 2000)

On 4 and 5 October 1999 the World Health Organisation (WHO), the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the German Federal Office for Radiation Protection (BfS) held an international seminar on the topic "Effects of Electromagnetic Fields on the Living Environment" in Munich-Ismaning. In the introduction M. H. Repacholi, International EMF Project of the WHO, said:
"By comparison, influences of these fields on plants, animals, birds and other living organisms have not been properly examined. Given that any adverse impacts on the environment will ultimately affect human life, it is difficult to understand why more work has not been done. There are many questions that need to be raised: …" and "...it seems that research should focus on the long-term, low level EMF exposure for which almost no information is available. Specific topics that need to be addressed include: … EMF influences on agricultural plants and trees" (MATTHES et al. 2000).
However, the German Federal Office for Radiation Protection (BfS) did not initiate any scientific research with respect to long-term effects of low EMF exposure on plants in the following time. The conduct of the BfS is contrary to the WHO request of October 1999 and it is contrary to the precautionary principle (BREUNIG 2013).
Balmori observed alterations in trees in the vicinity of mobile phone base stations in Valladolid, Spain, from the year 2000 on (BALMORI 2003, 2004).

Exposure tests

Roux et al. detected in numerous experiments in exposure chambers (900 MHz) that RF-EMF were influencing concentrations of various proteins in tomato plants (ROUX et al. 2006, 2008).
Sharma et al. found an influence on germination and growth of mung bean exposed to RF (900 MHz). In addition, they proved changes in enzyme activities (SHARMA et al. 2010).
Haggerty examined seedlings of aspens. In shielded plants, the shoot length increased by 74 %, the leaf surfaces by 60 % in comparison to sham-shielded plants. Number of leaves was identical. The leaves of the shielded plants developed no necrosis and showed autumnal colouring as well as production of anthocyans. The leaves of the exposed plants showed numerous leaf necroses and neither normal autumnal colouring nor anthocyan development (HAGGERTY 2010).

Statements of the German Federal Office for Radiation Protection (BfS)

Research results on plant damage caused by radiofrequency radiation, summarised above , were not taken into account for establishing the current limit values. In fact, the research data justify scientifical questioning of the existing legal threshold values and their protectiveness against harmful effects of radiofrequency electromagnetic fields on plants.

In view of these facts and although suspicious tree damages, that had occurred around mobile phone base stations, had been documented, the BfS drew the following conclusion on 18th of October 2008 : "Under the current conditions electromagnetic fields represent no apparent risk to damage of forest trees" (BFS 2008, translated from German).
In March 2010, the Bavarian State Government and the German Federal Government received a documentary about tree damage at 70 mobile phone base stations in the city and county of Bamberg from the the Physician initiative Bamberg Appeal (ÄRZTEINITIATIVE BAMBERGER APPELL 2010). Members of the Bavarian Parliament sent inquiries to the Bavarian State Ministry for the Environment and Health (RINDERSPACHER 2009, FAHN 2011).
On 1st of July 2011, the BfS added some scientific publications to its statement and ended with the following evaluation: "Although it is possible that plants respond physiologically to electromagnetic fields in the range of threshold values, harmful effects are not to be expected" (BFS 2011, translated from German).
Following the publication of a letter to the Bamberg City Council in June 2012 (ÄRZTEINITIATIVE BAMBERGER APPELL 2012) the Physician initiative received reports about tree damages from different parts of Germany (i.a. Hildesheim, see ANONYM 2012). On 9th of August 2012 the BfS added: "On the only condition that such observations accumulate strikingly and if no other plausible explanation is available, a possible connection with electromagnetic fields should be verified scientifically " (BFS 2012, translated from German).

Conclusion

Observations, that trees are getting damages by radiofrequency electromagnetic fields of mobile phone base stations, accumulate. Often, commonly recognized factors cannot explain the damage patterns. Therefore, the immediate scientific investigation of trees in the radiation field of mobile phone base stations as well as the evaluation of aerial photographs is necessary. Synchronously and shortly, exposure tests by using young trees have to be carried out.
In fact this conclusion is well supported by a WHO statement from 1999: **that scientific studies on effects of low EMF exposure on animals and plants are urgently needed** (MATTHES et al. 2000), a statement which can only be characterized as remarkable.

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References

ANONYM (2012): Baumschäden durch Mobilfunk, Moritz vom Berge, Stadtteilzeitung Hildesheim West, Nr. 231 (http://www.moritzvomberge.de/ausgaben/231/01_mobilfunk.html).

ÄRZTEINITIATIVE BAMBERGER APPELL (2010): Schreiben an Bayerische Staatsregierung (25.03.10) und Bundesregierung (18.04.10).

ÄRZTEINITIATIVE BAMBERGER APPELL (2012): Schreiben an Mitglieder des Bamberger Stadtrat (26.03.12), (http://www.bamberger-onlinezeitung.de/2012/06/28/zunahme-schwerer-baumschaden-im-strahlungsfeld-von-mobilfunksendeanlagen-2/).

BALMORI, A. (2003): The effects of microwaves on the trees and other plants, (http://www.hese-project.org/de/emf/WissenschaftForschung/showAuthor.php?lang=de&target=Balmori_Dr._Alfonso).

BALMORI, A. (2004): ¿Pueden afectar las microondas pulsadas emitidas por las antenas de telefonía a los árboles y otros vegetales? *Ecosistemas,* 13: 79-87.

BALODIS, V., BRUMELIS, G., KALVISKIS, K., NIKODEMUS, O., TJARVE, D., ZNOTIN, V. (1996): Does the Skrunda Radio Location Station diminish the radial growth of pine trees? The Science of the Total Environment 180:57-64.

BEAUBOIS, E.,GIRARD, S., LALLECHERE, S., DAVIES, E., PALADIAN, F., BONNET, P., LEDOIGT, G., VIAN, A. (2007): Intercellular communication in plants: evidence for two rapidly transmitted systemic signals generated in response to electromagnetic field stimulation in tomato, Plant Cell Environ, Jul, 30 (7):834-44.

BERNATZKY, A. (1986): Elektromagnetischer Smog - Feind des Lebens, Der Naturarzt 11:22-25 (http://www.diewellenbrecher.de/pdf/bernatzky.pdf).

BERNATZKY, A. (1994): Baumkunde und Baumpflege, Bernhard Thalacker Verlag Braunschweig.

BFS - BUNDESAMT FÜR STRAHLENSCHUTZ (2006): Protokoll des Fachgesprächs zum Thema „Gesundheitliche Auswirkungen der elektromagnetischen Felder des Mobilfunks – Befundberichte“, Bundesamt für Strahlenschutz, Neuherberg, 02.08.06, (http://www.emf-forschungsprogramm.de/veranstaltungen/protokoll_fallbeispiele_111206.html).

BFS - BUNDESAMT FÜR STRAHLENSCHUTZ (2008): Stellungnahme zur Frage möglicher Wirkungen hochfrequenter und niederfrequenter elektromagnetischer Felder auf Tiere und Pflanzen vom 18.10.08.

BFS - BUNDESAMT FÜR STRAHLENSCHUTZ (2011): Stellungnahme zur Frage möglicher Wirkungen hochfrequenter und niederfrequenter elektromagnetischer Felder auf Tiere und Pflanzen vom 01.07.11.

BFS - BUNDESAMT FÜR STRAHLENSCHUTZ (2011): Stellungnahme zur Frage möglicher Wirkungen hochfrequenter und niederfrequenter elektromagnetischer Felder auf Tiere und Pflanzen vom 09.08.12.

BOOMAANTASTINGEN (2013): Unkown tree damage (http://www.boomaantastingen.nl/)

BORTELS, H.(1951): Beziehungen zwischen Witterungsablauf, physikalisch-chemischen Reaktionen, biologischem Geschehen und Sonnenaktivität - Unter besonderer Berücksichtigung eigener mikrobiologischer Versuchsergebnisse, Die Naturwissenschaften, Heft 8: 165- 176.

BRAUER, I. (1950): Experimentelle Untersuchungen über die Wirkung von Meterwellen verschiedener Feldstärke auf das Teilungswachstum der Pflanzen, Chromosoma, 3,(1): 483-509. (http://link.springer.com/article/10.1007%2FBF00319492).

BREUNIG, H. (2013): Das BfS und die Baumschäden, ElektrosmogReport 19(4): 2-5.

BU'NDESNETZAGENTUR (2013): die EMF-Datenbank der Bundesnetzagentur (http://emf3.bundesnetzagentur.de/karte/Default.aspx).

COUSTET, E., WEISS, E-H. (1924): La T.S.F. pratique, Telegraphie, Telephonie, Librairie Hachette.

DEHOS, A. (2007): Bundesamt für Strahlenschutz, Schreiben vom 13.11.07.

ERMER, K. (1989): Waldsterben durch Elektrosmog, Video-Dokumentation Gymnasium Bayreuth, Film Nr. 36, (http://www.youtube.com/watch?v=5xbDJNFxAjU&feature=related).

FAHN, H. (2011): Anfrage vom 21.02.11, Bayerischer Landtag Drucksache 16/8272.

GOLDSWORTHY, A.(2006): Effects of electrical and electromagnetic fields on plants and related topics. In: VOLKOV, A.G. (ed.) Plant electrophysiology – theory and methods, Springer Verlag, Berlin Heidelberg: 247-267.

HAGGERTY, K. (2010): Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings: Preliminary Observations, Int. Journal of Forestry Research, Vol. 2010, Article ID 836278.

HARTE, C. (1950): Mutationsauslösung durch Ultrakurzwellen, Chromosoma 3: 140-147.

HARTE C. (1972): Auslösung von Chromosomenmutationen durch Meterwellen in Pollen-mutterzellen von Oenothera, Chromosoma 36(4): 329-337, (http://link.springer.com/article/10.1007%2FBF00336791).

HOMMEL, H., KÄS, G. (1985): Elektromagnetische Verträglichkeit des Biosystems Pflanze, Allgemeine Forst- und Jagdzeitung 156(8): 172-174.

HOMMEL, H.(1985): EMV von Biosystemen - Mensch, Tier, Pflanze. Überlegungen zur elektromagnetischen Verträglichkeit(EMV), Umwelt und Technik 8(4): 6-13.

HOMMEL, H. (1986a): Schadfaktor und Stress? Elektromagnetischer Smog, Frequenzganganalyse am Koniferen-Nadelkollektiv, Umwelt und Technik 9(1): 41-56.

HOMMEL, H. (1986b): Schaden die elektromagnetischen Wellen? Umwelt und Technik 9(4): 36-40.

KALNINS, T., KRIZBERGS, R., ROMANCUKS A. (1996): Measurement of the intensity of electromagnetic radiation from the Skrunda radio location station, Latvia, The Science of the Total Environment 180 (1996) 51-56.

KIEPENHEUER, K.O., BRAUER, I., HARTE, C. (1949): Über die Wirkung von Meterwellen auf das Teilungswachstum der Pflanzen, Naturwiss. 36: 27.

KOCH, W., Lehrstuhl für Forstbotanik der LMU München, (1989): Der Reinluft/ Standortsluft-Vergleich an Fichte, Forstw. Cbl. 108.

LERCHL, D., LERCH, A., HANTSCH, P., BITZ, A., STRECKERT, J., HANSEN, V. (2000): Studies on the Effects of Radio-Frequency Fields on Conifers, Kurzmitteilung auf der Tagung der Bioelectromagnetics Society in München, (http://www.boomaantastingen.nl/EMF_and_conifers%5B1%5D.pdf).

LERCHL, A: (2007): Schreiben vom 09.01.07 an Bayerisches Staatsministerium für Umwelt und Gesundheit.

LFU – BAYERISCHES LANDESAMT FÜR UMWELT, LUBW – LANDESANSTALT FÜR UMWELT, MESSUNGEN UND NATURSCHUTZ BADEN-WÜRTTEMBERG (Hrsg.) (2010): Elektromagnetische Felder im Alltag, Aktuelle Informationen über Quellen, Einsatz und Wirkungen, 2. Aufl., LfU Augsburg, LUBW, Karlsruhe.

MATTHES, R., BERNHARDT, J.H., REPACHOLI, M.H. (2000): Effects of electromagnetic fields on the living environment, Proceedings International Seminar on Effects of Electromagnetic Fields on the Living Environment – Ismaning, Germany, October 4 and 5, 1999, ICNIRP 10/2000.

MURAJI, M., ASAI, T., TATEBE, W. (1998): Primary root growth rate of Zea mays seedlings grown in an alternating magnetic field of different frequencies, Bioelectrochemistry and Bioenergetics 44: 271-273.

PLATTHAUS, H.-J. (1985): Waldsterben durch Mikrowellen, Frankenpost 4./5.5.1985 (http://www.diewellenbrecher.de/pdf/ermerfrankenpost.pdf).

RIESENHUBER, H. (1990): Schreiben vom 28.02.90 an Dr.-Ing. W. Volkrodt.

RINDERSPACHER, M. (2009): Anfrage vom 03.09.09, Bayerischer Landtag Drucksache 16/2504.

ROUX, D., VIAN, A., GIRARD, S. et al. (2006): Electromagnetic fields (900 MHz) evoke consistent molecular responses in tomato plants, Physiologia Plantarum 128: 283-288.

ROUX, D**.,** VIANi, A**.,** GIRARD, S**.,** BONNET, P**.,** PALADIAN, F**.,** DAVIES, E**.,** LEDOIGT, G**.** (2008): High frequency (900 MHz) low amplitude (5 V m-1) electromagnetic field: a genuine environmental stimulus that affects transcription, translation, calcium and energy charge in tomato, Planta 227 (4):883-891.

SCHORPP, V. (2006): Kasuistiken von Vorortuntersuchungen als Methode zur Ableitung kausaler Zusammenhänge, Fachgespräch BfS, 02.08.12, Oberschleißheim (http://www.puls-schlag.org/download/Schorpp-BfS-02-08-2006.pdf).

SCHORPP, V. (2011): Tree damage from chronic high frequency exposure, The effect of electromagnetic radiation on trees, First symposium February 18, 2011, Lecture, Baan, Netherlands (http://www.puls-schlag.org/download/Schorpp-2011-02-18.pdf).

SELGA, T., SELGA, M. (1996): Response of pinus sylvestris L. needles to electromagnetic fields. Cytological and ultrastructural aspects, The Science of the Total Environment 180:65-73.
SHARMA, V.P., SINGH, H.P., KOHLI, R.K., BATISH, D.R. (2009): Mobile phone radiation inhibits Vigna radiata (mung bean) root growth by inducing oxidative stress, The Science of the Total Environment, 407 (21): 5543-5547.

SHARMA, V.P., SINGH, H.P., BATISH, D.R., KOHLI, R.K. (2010): Cell phone radiations after early growth of Vigna radiata (mung bean) through biochemical alterations, Zeitschrift für Naturforschung C, 65(1-2): 66-72.

STUMGV – BAYR. STAATSMINISTERIUM FÜR UMWELT, GESUNDHEIT UND VERBRAUCHERSCHUTZ (2007): Mobilfunk, München.

TKALEC, M., MALARIC, K., PAVLICA, M. et al. (2009): Effects of radiofrequency electromagnetic fields on seed germination and root meristematic cells of Allium cepa L., Mutation Research, 672 (2):76-81.

VAN LAMMEREN, A., VAN KUIK, F., (2007): Phloem nodes deface trees and shrubs in urban environments (Manuscript for Arborist news dd 2-10-2007 (www.boomaantastingen.nl/Manuscript.doc).

VOLKRODT, W., (1987): Wer ist am Waldsterben schuld? Mikrowellensmog der Funk- und Nachrichtensysteme, raum & zeit, 26:53-62.

VOLKRODT, W. (1991): Droht den Mikrowellen ein ähnliches Fiasko wie der Atomenergie? Wetter- Boden- Mensch 4:16-23.

WALDMANN-SELSAM, C. (2007): Mikrowellensyndorm – ein neues Krankheitsbild, Vortrag 6. Rheinland-Pfälzisch-Hessisches Mobilfunksymposium,14.04.2007, BUND Rheinland-Pfalz, Mainz,Tagungsband, (http://www.bund-rlp.de/fileadmin/bundgruppen/bundrlp/Publikationen/Tagungsbaende/Mobilfunksymposium/6._Mobilfunksymposium/waldmann-selsam_mainz_2007.pdf).

WALDMANN-SELSAM, C. (2010): Wirkungen elektromagnetischer Felder auf Pflanzen, Beobachtungen und Studien aus 80 Jahren, Internet-Publikation der Kompetenzinitiative (http://kompetenzinitiative.net/KIT/KIT/mobilfunk-risiken-pflanzen-umwelt-elektromagnetische-felder/).